HOW PLACE-BASED EDUCATION INCREASES STUDENT INTERPRETATION OF MINNESOTA'S LANDSCAPE AND GEOLOGIC PROCESSES

by

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Epigraph

The world is the geologist's great puzzle-box;
he stands before it like the child to whom
the separate pieces of his puzzle remain a mystery
till he detects their relation and sees where they fit,
and then his fragments grow at once into
a connected picture beneath his hand.

-Louis Agassiz (1866) *Geological Sketches*

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INTRODUCTION

Understanding the Earth

Learning about what has happened to a landscape over time can provide great perspective in many ways. When one understands what their home was like hundreds, thousands and millions of years ago, one can feel a sense of place and connection to their time with that land. One can learn how to read the land and imagine its past to learn how the land used to be. Perhaps it was covered by a great sea or formed by the awesome power of a volcano melting the crust of the Earth. I realized that my life experiences thus far have helped me appreciate and understand how to read landscapes and the underlying geology of an area. I was curious if I could bring this into a classroom in order for students to build a sense of place and a connection to the world around them. Through reflection of my life and how I developed an understanding and skills in geology, I developed my focus for this capstone. My research question is: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?* I will investigate why place-based education and interpreting and understanding geology matters to student education and lifelong learning.

There is a sense of pride when one can look at a rock or landscape and understand what caused it to be that way. I want my students to understand how land used to exist in the past and the potential for its future. I want my students to not memorize information

and replicate it but to take a challenge head on and problem solve through it. I want my students to understand what has happened to a landscape over time, what can happen to it in the future and what must be done in order to take care of it.

In chapter one, I will describe my personal journey and how it led me to this question. I will also explain why this question needs to be addressed and why students need to develop this skill.

The Journey

My journey has three parts: my family and growing up, my undergraduate experience and my professional experience.

My family and growing up. I consider my childhood to be more outdoorsy than many of my childhood friends' experiences. My parents both liked exploring new, natural places and that continued when they had children. As a two year old, I accompanied them on a camping trip all around Lake Superior. As I went from an only child to the oldest sibling with two younger brothers, our adventures increased. The three of us would spend most of our free time outside playing, making up stories and games, climbing trees, building snow forts, sledding and exploring. As a family we traveled to countless state parks and historic sites in Minnesota, reading the interpretive signs along our hikes, watching for wildlife and enjoying the natural scenery. We went on a road trip to Montana and arrived after dark to our camping destination. I remember waking up the next morning in awe of the beauty of the scenery of a mountain stream and giant mountain landscape all around. I remember being fixated on a question of, "how does a river start at the top of a mountain," not understanding groundwater at the time. My

family also always had a vegetable garden that we rented from the city because the soil on our property was too sandy. We would spend countless hours planting seeds and plants, pulling weeds and watering. Since I grew up seeing where some of my food came from, I was less likely to waste it and also made sure to compost the scraps.

I was also involved in Girl Scouts from second grade to senior year where we had a core group to go camping, exploring and appreciating nature. Outside of my family and close friends, it was not until the fourth grade, and having a teacher dedicated to making sure her students understood environmental issues, that I even considered thinking about how science could be more than just a subject in school. Her environmental passion passed on to me, in our lessons on recycling, conserving water, gardening, composting, nature journaling, and appreciating the land as it is. We still keep in touch and I credit her for seeing my love of nature and kindling it further.

I was a YMCA camp counselor for four summers and was shocked after my interview being told I had the most experience in traditional camping skills (setting up a tent, nature hikes, canoeing, survival skills). I was given the charge to teach that special camp program throughout the summer. I was still ignorant of the fact that many others did not have the same background as I had. I enjoyed helping campers build their appreciation of the natural world and some basic understandings of the land. Throughout my childhood years, I was exposed to many locations around the state and country and started building background knowledge that I could reference as an adult trying to understand where I live.

My undergraduate experience. I went to Winona State University for my undergraduate experience. I started as an Elementary Education major with an emphasis in Social Studies. I was able to choose my two elective science courses because science was not my emphasis. I chose Natural Disasters and Dynamic Earth. These two courses were extremely engaging and I was inspired to earn the best grade I could. The Dynamic Earth course was known to be one of the hardest introductory lab courses, but I studied immensely, asked questions, was challenged but not beyond my potential and earned an A. By the end of my freshman year I had switched my emphasis from Social Studies to Science partially due to my academic success, but also partly because I noticed many more Social Studies education undergraduates than Science and wanted less competition.

In my sophomore year, I took more science and education courses. The summer between my sophomore and junior year, I took a month-long course on how to teach science in an elementary education setting. One of the weeks of the course we were joined by local science teachers and were trained in a curriculum called Project Water Education for Teachers (Project WET). Our focus was on the flooding of 2007 in southeastern Minnesota. I loved the active field investigations we did such as finding evidence of flooding, improving our understanding of the landscape and how water affected it. By the end of that week, a few of the professors came up to me and asked me what my plans were after I graduated. I told them I wanted to teach science in 5th or 6th grade in an elementary school. They told me how impressed they were of my engagement over the week and asked if I would consider an Earth Science Teaching major instead of

the Elementary Science major. I talked it over with my parents and they were fully supportive of making this change even though it would take me an additional year.

I switched my schedule for the fall of my junior year to Chemistry, Astronomy, Minerals and Rocks, Field Investigations and an education course. It was the most challenging and rewarding semester I had at Winona. In my field course, I traveled to Duluth and St. Cloud to make observations and try to determine what happened to the areas geologically. It was very difficult to do this without having some of the skills and content background the other students already had from being in a Geology program full time, but I did my best to keep up. We also explored the local landscape of Winona to try and develop an understanding of the geology of Minnesota in full. These field-based experiences gave me skills in interpreting a landscape and understanding its geologic history. I made a new set of friends in the Geology department and never looked back.

Through the rest of my time at Winona, I continued to enroll in many Geology courses and also was a Teaching Assistant for Astronomy (including helping run the on-campus observatory) and Historical Geology courses. This gave me a chance to see if I enjoyed helping people learn about Earth and Space Science. I truly loved the rest of my experience at Winona. I also took my Science Teaching Methods course where my professor ingrained in us to teach beyond what he called “memorize and puke,” referring to having students only learn something for an assessment and then forget it forever. This idea has stuck with me through all my roles in educating children. One of my goals is for students to develop an understanding of a topic and not just knowledge of vocabulary. My journey through my undergraduate education helped me develop a sense of place in

Minnesota, strategies to understand how Minnesota came to be geologically and methods to teach these skills to eighth-grade students.

My professional experience. My journey to find a full-time teaching position took me longer than I anticipated. I was a day-to-day substitute teacher for a year in a few different districts before I was hired to be a long-term substitute for two positions in Twin Cities metro area middle schools. Then I found a full-time position at another local middle school and stayed only a year because the following year's needs would have dropped my hours below full time. Highlights of these experiences include assisting students in projects on Minnesota Iron Ore mining and helping students learn about what was under their city by studying the well index data, which recorded what types of rocks were being drilled through and drawing out a rock cross section. I did notice that students were most engaged when learning about their city or state.

I found another Twin Cities metro area school and now have been teaching there for the past 5 years. I love the students, staff and general feel of the district. In all of my teaching positions, I found that students do not travel to many state parks or go on vacation for the sake of being in a place of nature. In my current position, I teach curriculum related to understanding how water travels over and through Minnesota, how climate change affects Minnesota and how geologic processes and glacial movement shaped Minnesota's landscape. I have tried different methods to help students develop their own understanding and am still searching for one I can implement. This capstone will help students in their interpretation skills and ability to understand their surroundings which could lead them to take action in a local project. I will be using my place-based

education curriculum design project to help answer my research question and help my students in their education.

Most summers I find professional development to increase my understanding of geology and pedagogy. I was a student in Hamline University's Teaching Inquiry-based Minnesota Earth Science (TIMES) project for three summers and attended the Minnesota Minerals Education Workshop (MMEW) for seven summers. Both of these experiences I found to be exceptional in what they were trying to accomplish. These experiences were held in different areas across the state to promote understanding of the geology of a region. The TIMES project was a graduate-level course which focused on the idea of having students participate in inquiry, record observations and ask questions and wonderings. Then students should write out claims and find evidence to support their claims and reasoning to justify it. Students might not find a correct answer, as it all depends on how the interpretation goes. MMEW is a three-day workshop with the first day being classroom learning and the next two days being field-based learning. In both of these experiences, we were allowed to go places often forbidden to the general public and gleaned great wonders about our state.

This past year MMEW was based in Grand Rapids, MN and one of the topics I learned about was a mineral resource I have never explicitly taught about - peat. I took a short course on it and during the field trip days, toured two peat harvesting and processing facilities. According to P. Jones (personal communication, June 18, 2019), peat is partially decomposed plant matter found in low lying depressions which accumulates over time, growing in these places because the water table is at the surface

and the plants get submerged slowing their rate of decomposition. The peat is harvested and used in farming and water remediation. Gaining this new understanding about part of Minnesota helps me appreciate my state even more and in learning something new and experiencing it in multiple perspectives, I am more likely to help my students understand it better as well.

I am also a board member of Minnesota Earth Science Teachers Association. We plan an annual conference to promote the profession. Being a part of TIMES, MMEW and MESTA I have met some Earth Science teachers who are great mentors to me. All three of these experiences helped build not only my background knowledge, but also positive connections to other teachers across the state.

My field-based Master's courses continued to hone my focus towards my capstone. The Biomes course focused on scientific change over time to a landscape, learning about the various ecosystems and connections between them across the state and how it has changed since Minnesota was covered with a glacier. The Environment and Society course focused on how who tells the story greatly influences how land is used. There are many versions of a single piece of land and these versions are valid and important to understand. These two classes gave me an in-depth look into content I did not get in my undergraduate education and will tie in the ecology and human perspectives along with the geology for my content component of my capstone project.

Finally, I need to give credit to my husband for continuing to learn with me on this journey. We met in the Winona State University Astronomy club, he graduated with a Geology degree and myself an Earth Science Teaching degree. We have traveled on

vacations to build our knowledge and shared interest of geology and astronomy. We choose places for their natural and geological attractions more than human built ones. Some highlights have been Yellowstone National Park, Wyoming to see the Total Solar Eclipse of 2017, Badlands National Park, Pipestone National Monument and Cloquet, MN to learn together about Native American astronomy. We both love being outside and exploring nature. Being connected to nature and having a heightened sense of place means I like learning from the land in many realms. Traveling and exploring new places further grows my understanding of the world and enables me to practice my skills of landscape interpretation and better understand the geologic history of an area.

Chapter Summary

I have described how my upbringing led me to be the environmentally conscious, inquisitive thinker that I am who is curious about how Minnesota's landscape came to be. I plan on developing curriculum for students to acquire skills to interpret a landscape and its geology to understand how it came to be. The goal of this curriculum is for students to feel a connection with the land and a sense of place.

In chapter 2, I will demonstrate the value of place-based education, justify why understanding the landscape and geology is needed for students to be lifelong learners and touch on culture (who tells the story) by reviewing literature. In chapter 3, I will explain my project and how it will be used. In chapter 4, I will reflect on the capstone consider my key learnings and how future teachers could expand on my curriculum.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter explores previous research completed by others and supports the investigation of my research question: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?* The following sections will explain how the integration of place-based education, the development of landscape interpretation skills, the scientific content of the landscape and geology of Minnesota and the implementation of the present and upcoming Minnesota science standards will all support the formation of curriculum for the project design. The overall goal is to assist students in understanding where they live and help them develop a sense of place to their surroundings so they can make educated decisions on how to live in and take care of the environment.

The purpose of examining the concept of place-based education is to demonstrate a teaching method that has been shown to help students understand science concepts, connect to a place and live sustainably in their community. One way to connect to a place is to learn what a place can tell about how it formed and this can be done by learning how to interpret the physical landforms and learn from community members past and present. Specific details about the geology and ecology of a place will further assist students in learning the story of a place. All of these pieces connect directly to state science

standards and therefore can be implemented easily into building curriculum for a school year.

Place-based Education

Place-based education (PBE) is teaching and learning focused on a specific, local place through interdisciplinary experiences (Semken, Ward, Moosavi & Chinn, 2017). Semken et al. (2017) specifically defined PBE as "a situated, context-rich, transdisciplinary teaching and learning modality distinguished by its unequivocal relationship to place, which is any locality that people have imbued with meanings and personal attachments through actual or vicarious experiences" (p. 542). The phrase "place-based education" was first put into academic writing at the end of the 20th century; the idea and practice date back to Native Americans (Semken et al., 2017). One example of how a Native American view of place can be explained is:

> Power and place produce personality. This equation simply means that the universe is alive, but it also contains within it the very important suggestion that the universe is personal and, therefore, must be approached in a personal manner… The personal nature of the universe demands that each and every entity in it seek and sustain personal relationships… Indian knowledge of the universe was never separated from other sacred knowledge about ultimate spiritual realities" (Deloria & Wildcat, 2001, p. 23).

This idea shows how one can be connected to nature and know about a place in a very personal way. The purpose of PBE is for students to better understand and be able to live sustainably in their community (Semken et al., 2017). The learning outcomes for

PBE include the science knowledge of the place (example: climate), diverse meanings (example: local traditional knowledge), authentic experiences (example: fieldwork), sustainable practices and the development of a sense of place (Semken et al., 2017).

PBE is also defined by organizations helping teachers use PBE teaching practices. Lowenstein, Grewal, Erkaeva, Nielsen and Voelker (2018) used the Great Lakes Stewardship Initiative's definition—"a hands-on, inquiry-based, contextually embedded, and community-supported approach to teaching and learning that occurs in and with a place or community, is about a place or community, and yields benefits for a place or community" (p. 39). This definition focuses on integrating specifics in teaching methods and community involvement.

Lowenstein et al. (2018) broke down PBE into three pedagogical practices: inquiry-based instruction, connection to place, and informed civic engagement. Place-based inquiry involves students investigating questions of interest to them, teachers keeping educational goals in mind, and students finding issues in their community that need to be addressed. Teachers and community members act more as a guide than their traditional formal roles. For students to connect to a place, they must be a part of a community of not only humans but other beings in nature and the living systems. Students should find value in community strength and wisdom and consider how their actions affect the community. Lastly, students will learn how to be informed citizens and engage in the community. Students will learn about issues affecting many different people in their area, learn from multiple perspectives, and learn how to use their voice to

find solutions to these problems (Lowenstein et al., 2018). These three practices of PBE are integrated together to help build a person's relationship to a place is the focus of PBE.

Sense of place. *Place* is defined as a locality or space that has meaning from human experience (Semken, Freeman, Watts, Neakrase, Dial & Baker, 2009). These place meanings can be humanistic or scientific, are built from ways individuals and groups know and experience the place and also include emotional attachment (Semken et al., 2009). The combination of the place meanings and place attachments is known as the *sense of place*. Sheppard, Lipson, Hansbrough, and Gilbert (2013) defined *sense of place* as a combination of the geology, ecology and cultural history of an area. Place attachment is defined as an emotional bond to a place that comes from direct experience (e.g., living, working or visiting), indirect engagement (e.g., books or media), or a combination of the two (Semken et al., 2009). One does not have to have been to a location to have an attachment to it. A personal example is that I listened to an audiobook and watched documentaries on New Orleans about the area being hit by Hurricane Katrina before going to the location. I felt an emotional connection to that city and when I finally traveled there, I felt like I had a better understanding of how and why the area flooded and the plight of its citizens. Place meanings can be spiritual and scientific and come from those who produce the meaning and those that consume it. The producers, like teachers or tour guides, provide information about a place and consumers, like students or tourists, construct the meaning (Semken et al., 2009). One way students develop a sense of place is by learning about the land.

Connections to the land. Place meanings can be separated by types such as "ecological, cultural, aesthetic, architectural, familial, political, and economic meanings" (Russ, Peters, Krasny, & Stedman, 2015, p. 74). Ecological place meaning comes from how phenomena in ecosystems are seen as valued or important parts of a place, including natural habitats, green infrastructure, environmental stewardship and outdoor recreation. Viewing nature as a part of a place promotes pro-environmental actions - if one sees a place as meaningful to them, one is more likely to want to protect it (Russ, Peters, Krasny, & Stedman, 2015).

Land-based education is another way to learn about the land. Hansen (2018) collected perspectives from Cree Elders of Northern Manitoba on land-based education. One perspective was on how the Cree used land for subsistence: hunting, fishing, living and healing. Respect is shown to the plants, animals and land, and the land is not considered owned but shared and used in ways that it will last for future generations. This example shows people forming a relationship with the land to ensure that it and everything on it will be respected. In addition to connecting to the land itself and coming up with their own place meaning, students must come together in their communities to connect to the land.

Connections to the community. Students need to be learning about their community when making meaningful connections to land. Students need to begin to realize that their place meanings might be different than their peers and others in the community, which does not make the place less valuable, but actually increases the diversity and understanding of the land (Deringer, 2017). Different cultural knowledge is

represented in different ways and allows for a more complex understanding of an area. As students build their sense of place, they will consider their environmental responsibility and environmental justice (Deringer, 2017).

Lowenstein and Smith (2017) noted that a teacher's role goes beyond just subject content and students, to someone who reaches out into the community to find people to help the students in their learning. They form relationships and partnerships with experts to provide background knowledge, perspectives and resources to the students. These community members must be seen as a necessary piece of understanding the cultural history of a landscape.

Cultural history. When learning about a place, and building meaning and attachment to it, one must realize there are many ways to understand a place. Coughlin and Kirch (2010) brought up that places are known as part of the natural world and it is important to learn about and take care of the natural world. A person's representation of the natural world depends on their worldview and there are many different stories about the same location. An example is some people seeing a nature park as a place that needs to be cleaned up and protected while others see it as land that was stolen, used to be a hunting ground for survival and was a sacred place for rituals (Coughlin & Kirch, 2010).

Hansen (2018) summarized one aspect of Indigenous land-based education perspectives from the Cree elders having a spiritual connection to the land. A Cree belief is that there is a spirit or soul that connects everything together and therefore each action has an effect on everything else. One might not find value in the spiritual meaning of a place, but one can learn to respect it. A PBE designed course must meld multiple

perspectives into the story. Local cultural themes can be taught with the geological processes to provide students an opportunity to get a deeper understanding of a place (Cook, 2018). An earth science professor at the University of Minnesota took this idea to revise one of their classes and told the story of the Falls of St. Anthony, the Mississippi River's only natural waterfall. The professor wove in the geologic history, how the waterfall helped found the city of Minneapolis, MN, how the Indigenous people used the resources in the valley of the waterfall and how the Euro-Americans altered the falls and almost destroyed them. This led to an industrial concrete apron being put over the falls to protect what was left of them (Cook, 2018). Depending on a person's worldview, they might not know multiple sides to this story and its cultural history. PBE with specific attention to connecting to many perspectives will help students make better connections to a place.

This literature specifically informs my capstone work because I want my students to develop a sense of place about their local area, find the knowledge meaningful and become emotionally attached to it so they can better care for it. I want my students to have a stronger connection to nature and the landscape to know how to use it responsibly. They need to learn from people who have lived there in the past and currently to see different perspectives of how to use the land. Many people have likely lived, used and changed an area so I want my students to understand many sides to its story. One part of this understanding comes from students developing skills in interpreting a location to learn its geologic past. This understanding provides a more objective way to view one's surroundings and can be accomplished in and out of the classroom.

Interpretation of a Landscape

Geomorphology is the "study of Earth surface processes and history" (Reusser, Corbett & Bierman, 2012, p. 3). Studying geomorphology is one way of learning the landscape. It includes studying physical processes, landforms and geologic history and parts of physics, chemistry and biology (Reusser, Corbett & Bierman, 2012). This section is about how students can use field observations, maps, photographs, satellite images and conversations with community members to learn about the geomorphology of a region and read the landscape. Including a wide variety of methods will help students get a more complete background and story of a location.

Field-based observations. When learning about the natural world, one should be immersed in it to be able to make relevant observations and interpretations. Students asking questions from their personal experiences are modeling what scientists do as they study the natural world and make explanations based on evidence (Martinez, Bannan-Ritland, Peters, & Baek, 2011). Students may not have had prior experiences in a specific natural setting and might have no way to know if their observations are common or unique, so they will need guidance and prompting after they explore an area and make the observations that make sense to them (Colson & Colson, 2017). Identifying the plant and animal species of an area and focusing on the indicator species of its biome can help one learn the unique conditions present in a landscape, and if indicator species are absent, it can indicate local environmental conditions have changed (Davis, 1971).

One way for students to synthesize what they understand about an area is through concept sketching. Concept sketches are labeled diagrams which students use to organize

information to show what they understand of the formation, processes and interactions between parts of a scientific concept (Reusser, Corbett, & Bierman, 2012). Students can collect observations and data out in the field, can combine it with classroom learning and develop a comprehensive picture of their understanding. The concept sketch should have four parts: identification, processes, interactions, and predictions for the future, to go beyond just basic knowledge (Reusser, Corbett, & Bierman, 2012). Going outside into the field and having students make observations and ask questions will get the students started into data collection. Drawing labeled diagrams of what the students see and how they can summarize their learning will help them build their understanding of a location.

Classroom observations. In addition to field-based observations and when locations are not able to be visited, students should continue to build their landscape interpretation skills through observations in the classroom. One way to do this is with topographic maps. Topographic maps are maps that display the shape and elevations of landforms using contour lines, which represent shapes of three-dimensional landscapes on a two-dimensional surface (Richardson, Sammons, & Delparte, 2017). Students can examine a topographic map of their area of study to see what the area looks like (or if using a series of maps made at different times, how the landscape has changed over time). Topographic maps are static representations in time and so to use more current information, teachers and students can use web-based dynamic tools.

Geographic Information Systems (GIS) is a framework for working with data through a software or online. Using GIS helps one analyze location data and this data can be layered to find patterns (Environmental Systems Research Institute, n.d.). Using GIS is

another way to interpret a landscape, but teachers can find it challenging due to a lack of instructional support and lack of time to design and use GIS in lessons (Hus, Tsai, & Chen, 2018). Google Earth (GE) is a free website with geospatial data and satellite images of Earth's surface. GE is an effective teaching method of using the information found in GIS software but in an accessible way in public schools with limited computer software and teacher training on GIS (Hsu, Tsai, & Chen, 2018). Using GE improves students' topographic map reading skills over just using paper topographic maps and aerial photographs due to students using the 3D visualization feature to improve their spatial thinking (Hus, Tsai, & Chen, 2018). The 3D visualization feature can overlay topographic maps and help students observe contour line patterns (Hus, Tsai, & Chen, 2018). Studying topographic maps can give students a different perspective than what can be seen observing a landform from the side. These maps can show change over time if different years are studied. GIS in the form of GE can be more relevant and up to date to further help students find patterns in a landscape.

Community member stories. In addition to using topographic maps and web-based technology to assist in understanding a landscape, one must also communicate with those who live there now and learn about those who lived there in the past. Teachers must carefully consider what stories their students learn about a landscape, whose land it has been and how it has changed over time (Stewart, 2008). These stories should not be seen as objective or neutral, although they should not be seen as useless, but should be seen as a way for one to give meaning to the natural world. If a part of the story is purposefully left out, then there is a power imbalance and the story is not valid (Stewart,

2008). According to Stewart (2008), “there is no single history of a place: different stories reveal different values, attitudes, behaviours and impacts” (p. 94).

Including local oral traditions in the science classroom brings more of the community knowledge back into science education (Stapleton, 2017). Community members, especially rural families, can have considerable ecological, medicinal and agricultural knowledge from their experiences with the land. Language in science classes can be difficult due to the amount and complexity of terms and verbage and if students do not feel represented, they may disengage. When colloquial talk is used in science classrooms, students were at least three times more likely to be engaged (Stapleton, 2017). This strategy allows students to use the words that they know to describe an observation or inference versus focusing on explicit vocabulary. Students should want to bring in their background knowledge and personal interpretations into the classroom. Students can interview elders in their community to learn about area-specific cultural and ecological knowledge to understand it and to pass it on to future generations. When learning through oral traditions, teachers must be careful about not letting students consider them trivial, primitive or inferior to science (Stapleton, 2017). In learning from members in the community, students can learn about how an area was in the past and consider how to take care of it now and in the future.

This literature specifically informs my capstone work because I want my students to use many techniques to interpret a landscape. Students need to learn how to study the geomorphology of an area by going outside, making observations and asking questions. They will identify indicator species to determine specific scientific information and

construct concept sketches to show what they understand. Students will come back inside and use topographic maps and Google Earth to become more spatially aware of their surroundings. Students will also interview community members and learn multiple perspectives of a given location. Students will be encouraged to use their cultural and background knowledge to explain their understanding of a landscape and consider how to take care of an area.

Minnesota's Landscape and Geology

Minnesota's landscape can be interpreted using different lenses. This section will explore the geology and biomes of Minnesota to build background knowledge and tell the story of Minnesota.

Minnesota's geology. The landscape of Minnesota has a very old story, almost as old as the Earth itself. Minnesota has many parts of its past exposed at its surface and the pieces can be put together in chronological order to tell its geologic story. See Figure 1 to visualize where in Minnesota one can find the different bedrocks at and under the current landscape. The oldest part of Minnesota is made up of 3.6 billion year old metamorphic rock called gneiss, found mostly in today's Minnesota River Valley (Ojakangas, 2009). This rock formed under intense heat and pressure deep in the Earth's crust. Since this is a very old rock exposed at Earth's surface, and this rock formed deep underground, this is evidence that Minnesota had a different landscape in the past than it does now, with the rock either being uplifted or other rocks being weathered and eroded away sometime since their formation 3.6 billion years ago. The gneisses were part of a microcontinent and this landmass collided with the granite and greenstone rocks of the Canadian Shield

(part of the North American craton). Due to the action of plate tectonics it was partially forced down, or subducted, beneath it, causing the landmasses to combine to form northern Minnesota (Ojakangas, 2009). East of this new landmass was the ocean and before the next collision of another microcontinent, the ocean floor was subducted and melted beneath this landmass. The melted rock, magma, rose to the surface as lava and cooled into basalt, an igneous rock 2.7 billion years ago (Ojakangas, 2009). This basalt can be found in northeastern Minnesota with an excellent outcrop of pillowed basalt in Ely, MN. Minnesota also has remnants of mountain ranges that eroded down between 2.7 billion years ago and 2.0 billion years ago, which allowed space for sand to be deposited on what is now northern Minnesota. This sand with time, heat and pressure, metamorphosed into quartzite in northern Minnesota and the 700 million year period of erosion indicates a time of calm for Minnesota and lack of tectonic activity (Ojakangas, 2009).

One of Minnesota's most well known mineral resources is its iron ore. Ojakangas (2009) continues to explain Minnesota's complex geology. The Iron Ranges of Minnesota formed 1.9 billion years ago when iron and silica were deposited in a shallow sea in northern Minnesota. More quartzite formed in now southwestern Minnesota from the weathering of granite and the erosion of the quartz in ancient mountains 1.7 billion years ago (Ojakangas, 2009). About 1.1 billion years ago, a mid-continental rift system caused sections of the North American landmass to start to split apart, allowing some of the molten rock to come up to the surface cooling into basalt and some molten rock to cool and harden underground forming gabbro - both of these can be found on the north

shore of Minnesota. 500 million years ago, Minnesota was located at the equator and covered by a shallow sea teeming with sea life. When the organisms died, they became fossils in limestone, with sandstones and shales also being deposited at this time - these can be found in southern and southeastern Minnesota (Ojakangas, 2009).

The climate cooled 1.8 million years ago - 10,000 years ago and Minnesota was covered with ice in an ice age. Glacial lobes covered most of Minnesota during this time except for the Driftless Area in southeastern Minnesota (Ojakangas, 2009). The lobes deposited glacial till and made many landforms we see across Minnesota today - moraines, kettle lakes, eskers, scour lakes, drumlins, and glacial potholes (Ojakangas, 2009). But Minnesota's landscape is more than just a bunch of old rocks. Its landscape has been covered by organisms for billions of years and those lifeforms also tell a story.

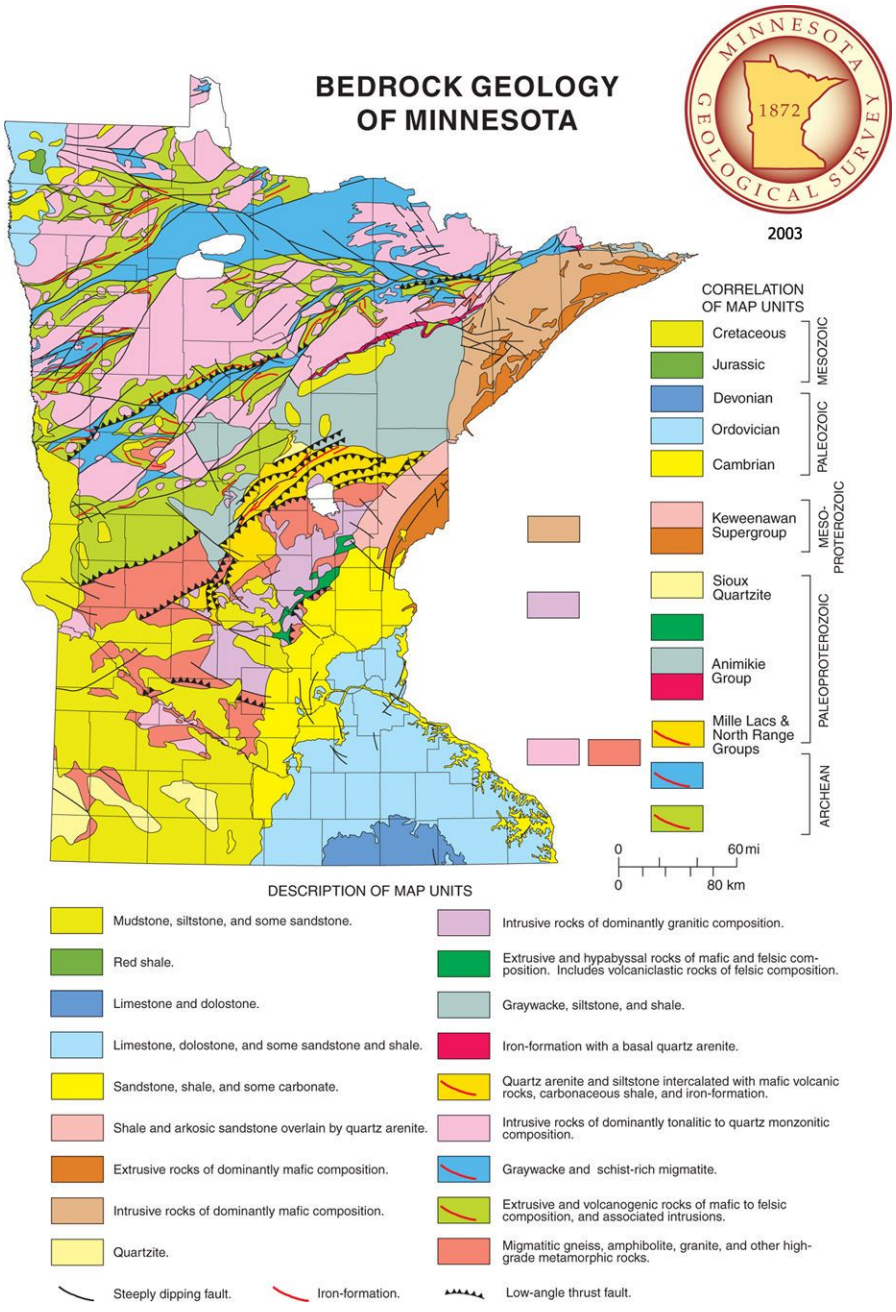

Figure 1. Bedrock Geology of Minnesota. This figure illustrates the rocks found under the landscape in Minnesota and the time periods in which they formed. (Tipping & Lusardi, 1996).

Minnesota's biomes. Minnesota is located in the middle of North America and has specific conditions of climate, geology, and soil to support the ecology of the three main biomes in Minnesota - deciduous forests in the northwest to southeast, coniferous forest in the northeast and prairie to the west (Tester, 1995). Tester (1995) is a comprehensive survey of the ecosystems within these different biomes. The deciduous forest has seven tree types: maple-basswood, aspen, aspen-birch, paper birch, oak, northern hardwood and lowland hardwood. The mammalian animals include white-tailed deer, cottontail rabbits, woodchucks, bats, squirrels, chipmunks, mice, raccoons, skunks, bears, opossums and foxes. There are countless bird species due to the lush habitat the deciduous forest provides, including the great blue heron, wild turkeys, ruffed grouse and woodcock. For the amphibians and reptiles, these animals are shy and secretive so they are harder to observe, but some include the gray treefrog, fox snakes, gopher snakes, garter snakes, and rattlesnakes (Tester, 1995).

The coniferous forest is composed of red, white and jack pine with some aspen, birch, spruce, and fir mixed in (Tester, 1995). The mammalian animals include beaver, deer, moose, wolves, coyotes, snowshoe hares, and porcupines. The birds include woodpeckers, ruffed grouse, spruce grouse, hawks, owls, and bald eagles. The amphibians and reptiles are similar to those in the deciduous forest but fewer due to the colder climate (Tester, 1995).

The tallgrass prairie biome has three types: mesic, dry and wet (Tester, 1995). Before European settlement, the buffalo was the most important mammal on the prairie, eating everything and then moving on, allowing the prairie to recover. Now gophers and

badgers, white-tailed jackrabbit, mice, voles, shrews occupy more of the land. For birds, marbled godwits, upland sandpipers, prairie-chickens, sharp-tailed grouse and blackbirds are some of the major creatures. The amphibians and reptiles include the western chorus frog, leopard frog, Manitoba toad, salamander, prairie skink, plains garter snake, western hognose snake and gopher snake (Tester, 1995).

These biomes changed over time and are currently changing due to human development with most of the deciduous forest cleared and used for agriculture, many of the pine trees have been replaced with aspen and birch and less than 1% of the tallgrass prairie is left (Tester, 1995).

This literature specifically informs my capstone work because I want my students to have a deep understanding of the geology and ecology of wherever they are in Minnesota and transfer their skills to wherever they travel to in their future.

Minnesota Science Standards

The Minnesota Academic Science Standards that teachers are presently using have been in place since 2009 and are under review to be updated (Minnesota Department of Education, 2019). These standards are organized into content strands, substrands, standards and benchmarks. These standards are "expectations for achievement in science for K-12 students in Minnesota [and are] grounded in the belief that all students can and should be scientifically literate" (Minnesota Department of Education, 2009, p. 1). The Next Generation Science Standards (NGSS) are the base of the draft of the new standards and are explored in this section (Minnesota Department of Education, 2019a).

Present standards. The Minnesota Department of Education (2009) has the present 2009 standards broadly focused on students knowing content knowledge. An example content standard is students will understand that: “Landforms are the result of the combination of constructive and destructive processes.” This standard has two benchmarks, which are the learning outcomes: “Explain how landforms result from the processes of crustal deformation, volcanic eruptions, weathering, erosion and deposition of sediment.” and “Explain the role of weathering, erosion and glacial activity in shaping Minnesota's current landscape” (Minnesota Department of Education, 2009, p. 23). This example demonstrates what content students are expected to know but doesn’t go into detail about how these processes work.

New standards. The drafts for the updated Minnesota academic science standards more closely align with the recommendations given by the Committee on a Conceptual Framework for New K-12 Science Education Standards of the National Research Council of the National Academies (National Research Council, 2012). This framework includes a set of expectations for all students to achieve. The overall goal of this framework is that:

> By the end of 12th grade, all students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their

> choice, including (but not limited to) careers in science, engineering, and technology. (National Research Council, 2012, p. 1)

The NGSS are the result of this framework and are the standards that students should be able to achieve. The NGSS are divided into three dimensions: science and engineering practices, disciplinary core ideas and crosscutting concepts (NGSS Lead States, 2013). Each dimension is linked together to form a standard and with the standard having multiple dimensions, they are more about the process of doing science than the present Minnesota science standards, which focus more on students learning the content knowledge.

The drafts for the new 2019 Minnesota standards use the NGSS as their base framework (Minnesota Department of Education, 2019a; Minnesota Department of Education, 2019b). These standards might be fully implemented for the 2023-2024 school year after a study year next year and gradual implementation the following years. The new series of drafts have anchor standards instead of content standards and then has the content in the benchmarks with an emphasis added. An example of an anchor standard is

> "Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments" (Minnesota Department of Education, 2019b, p. 24).

An accompanying benchmark is:

> Construct an argument, supported by evidence, for how geoscience processes have changed Earth's surface at varying time and spatial scales. (P: 7, CC: 3, CI: ESS2) Emphasis is on how processes like erosion, deposition, mountain building, and volcanism affect the surface of Earth. Some processes, like mountain building take a long time. Other processes, like landslides, happen quickly. Examples may include how weathering, erosion and glacial activity have shaped the surface of Minnesota. (Minnesota Department of Education, 2019b, p. 24).

This example demonstrates a different way of addressing what skills students will possess upon the mastery of the standard. It has the focus of using evidence to explain phenomena (or find flaws in their own or others explanations) through the content of how Minnesota's landscape formed over time. This set of standard and benchmark can directly be developed into curriculum to support the answer to my research question.

In addition, the third draft of the new Minnesota standards has more focus and specific benchmarks on Native American teachings and culture. One example of a standard is for "students [to] be able to gather information about and communicate the methods that are used by various cultures, especially those of Minnesota American Indian Tribes and communities, to develop explanations of phenomena and design solutions to problems" with the benchmark that students will "communicate how a series of models, including those used by Minnesota American Indian Tribes and communities and other cultures, are used to explain how motion in the Earth-Sun-Moon system causes the cyclic patterns of lunar phases, eclipses and seasons. (P: 8, 2, CC: 1, CI: ESS1) Examples of cultures may include those within the local context of the learning community and within

the context of Minnesota. Emphasis is on students questioning the limitations of their models and revising them to account for new observations. Models may be physical, graphical or conceptual. (Minnesota Department of Education, 2019b, p. 24). This promotes multiple ways to learn the story of an area and not just focus on the perspective of one group.

The third draft of standards was sent to the Minnesota Commissioner of Education in May of 2019 and if approved, a final draft will be published (Minnesota Department of Education, 2019b). Teachers and students will be using these new standards at the earliest in the 2020-2021 school year. There will potentially be some adjustments in what grade levels are responsible for which science content, and how teachers will be able to teach content with potential variances to the licenses, so there will likely be some modifications to the specifics of these standards before they become final (Minnesota Department of Education, 2019b).

This literature specifically informs my capstone work because I want my students to become 21st century citizens in their understanding of science and using the upcoming set of Minnesota academic science standards will help them develop these skills. These standards build on the present standards and will enhance the focus of students doing the process of science.

Chapter Summary

Feeling a connection to a place helps one feel grounded and a part of a community. When one understands what a place used to be, one can determine if it is being used appropriately in the present and can take care of it in the future. When

students learn through place-based education, they can become attached to a place and draw meaning from it. When students learn how to interpret a landscape, they develop a skill that they can use wherever they go in their life to read the story of the land. When students understand the scientific background of a place, they develop an appreciation and an even deeper connection to a location and feel a part of its story. When teachers can justify the use of specific curriculum with standards, they can more easily integrate it into their yearly plan.

The above sections will support the development of curriculum and chapter three will describe the project to help develop an answer to the research question: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?* The chapter will include the audience, method, background theories and frameworks and timeline for the completion of the curriculum design. These pieces will combine together to help students and teachers find success with this specific application of place-based education.

CHAPTER THREE

PROJECT DESCRIPTION

Introduction

Place-based education (PBE) can help students develop a sense of place and connect to their surroundings. This increases their understanding of its past (scientific and cultural) and can make better educated decisions about how to take care of it in the future. This chapter describes the curriculum made to address the question: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?* A set of 16 days worth of PBE lesson plans were made for a Minnesota Landscape Interpretation unit and will be implemented in the 2019-2020 school year. Summarizing my conclusions from my literature review in chapter two, I find that the use of PBE increased a student's sense of place and connection to the land, which increased their ability to develop skills in interpretation of the land and understanding of its story. This enabled them to make more educated decisions about the land and to take better care of it. This chapter explains the rationale behind the unit, the setting and participants of the unit, how the curriculum was developed, how the learning is assessed and the timeline for project implementation completion.

Project Description

Some of the lesson plans will specifically include: going outside to make observations of the local landscape and collecting data to be included in a concept sketch;

researching what is under the ground in any location in Minnesota by looking it up in a student-friendly database to gain perspective on one's local surroundings; observing and interpreting a 3D map of the Upper Midwest area to locate glacial landforms, such as moraines and kettle lakes; using sand tables to model landforms made by moving ice and melt water such as glacial valleys and moraines; interviewing community members and contacting the local historical societies to learn about a location's past; and proposing a solution to a local problem or a way to demonstrate student understanding in a more public way.

Rationale

This unit used place-based education lessons to help the students learn about where they live and understand it scientifically (geology and ecology past and present) and also culturally (human population past and present) (Semken et al., 2017). There were opportunities for students to connect with community members to learn from them and do a community service project to connect to the land (rain garden, informational display, native planting, etc). I designed this curriculum because I have not yet found a complete unit already made that answered my research question directly. There were singular stand-alone lesson plans from various sources that were integrated and adjusted to fit into the unit, but nothing full and complete.

Setting and Participants

The setting for this project is a suburban middle school in the Midwest. At this school, there are about 70 adults - teachers, guidance, paraprofessionals, secretaries, health, custodians, kitchen staff and administration assisting students. There are about

700 students in sixth-eighth grade. The total student body is 91% white, 4% two or more races, 3% Hispanic or Latino, 1% Black, and 1% Asian. There are 14% of students in Special Education, and 7% of students qualify for Free/Reduced price lunch. Many students are in an upper economic class, but not all. Some live on multi-acre woodland or farmland and some live in town.

The participants will be 120 students in 4 eighth grade science classes in the 2019-2020 school year. I made this unit public so other Minnesota middle school teachers can use it in the way that works best for them. The skills of landscape interpretation are universal, but the geology, ecology and community stories of Minnesota specifically will have to be adjusted to the present location if using this project in a different state.

Curriculum Development Process

The curriculum was developed with the framework of Understanding by Design, developed by Wiggins and McTighe (2011). Understanding by Design recommends backwards curriculum design with results in mind so lessons have connections between each other and a purpose towards developing student understanding. To understand, a student must "make sense of and transfer their learning through authentic performance … [and be able to] explain, interpret, apply, shift perspective, emphasize and self assess" (Wiggins & McTighe, 2011, pp. 3-4). This unit has students building background knowledge through observation and interpretation of data of their local landscape to understand the stories of the land better in order to decide how to care for it and live with and on it.

Lessons include: going outside to make field-based observations, drawing concept sketches, using topographic maps and GIS through Google Earth, talking to members of the community and learning the cultural history (including current residents and Native Americans), learning the geology and ecology of the area, and recognizing their connection to the land and building their sense of place and perhaps finding solutions to local problems about place.

In order to have students take the skill of landscape interpretation and be able to apply it in new locations and use it in their future, they need to be motivated to learn it well in the classroom. Van der Hoeven Kraft, Srogi, Husman, Semken, and Fuhrman (2011) proposed a model specific to geoscience to motivate student learning. This model combines motivation, emotion and connections with Earth. Teachers who use this model to develop curriculum are trying to increase interest, or intrinsic value, which is a predictor for future learning. This result will help students value the content and go further in their learning. The models by Wiggins and McTighe (2011) and Kraft et al. (2011) were both consulted in the construction of the curriculum.

Curriculum Assessment

A survey begins the unit to determine what background knowledge students have coming into the unit. The survey questions focus on their current understanding of how Minnesota's landscape came to look the way it does now; what rocks and minerals can be found in Minnesota and why; what types of plants and animals live in Minnesota; and how did people use to live in Minnesota in the past. Formative assessments such as think/pair/share, individual reflections and class discussion are used to gauge student

understanding during the unit. Two summative assessments make up the last few days of the unit. Students will have gone outside on the first day of the unit to make initial observations. Students will again go outside to make connections between their new understandings on landscape formation, geology and biomes and the school grounds. Their goal is to add to their initial observations from the first day of the unit and to construct a concept sketch. Students will also design a solution to a local environmental problem and propose implementation. This solution will be based on their enhanced understanding of their local landscape, their increased development of their sense of place and feeling connected to the local area. The solution could be on or near the school grounds or near their own home. It could be an action to help the environment or a way to provide awareness to something students now understand about the area. These summative assessments will give evidence to support the answer to my research question: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?*

Chapter Summary

Chapter three detailed specifics of my PBE unit, the research that supported it, the setting, participants and timeline so it can be implemented in the 2019-2020 school year. In chapter four, I reflect on what I learned from the capstone process, which sources influenced my thinking the most, what my project will do for students, how I will use my project and any limitations to my project.

CHAPTER FOUR

CONCLUSIONS

Introduction

This chapter contains my reflection on my research question: *How can using place-based education help students interpret the landscape of Minnesota and increase their understanding of geology?* My overarching goal for this project is to assist students in understanding where they live and help them develop a sense of place to their surroundings so they can make educated decisions on how to live in and take care of the environment. This chapter describes what I have learned throughout this process, key findings from my literature review, implications and limitations of my project, recommendations to others interested in a similar project, my plan after implementing my project and why my project matters.

Learnings

Growing up, I was always fascinated by maps and figuring out what an area was like. I enjoyed reading informational displays at state parks and natural areas to learn more about the landscape. If possible, I tried to figure out where I lived on a map and where I was to, unknowing to my innocent self, develop my spatial thinking skills. During my undergraduate experience, I took more intentional courses on Minerals and Rocks and Field Investigations, where I improved my skills in landscape interpretation and understanding the geology of Minnesota. I still like to learn from maps of all types in building my understanding of Minnesota.

As I started my master's process in the spring of 2018, I wasn't quite sure exactly where I wanted to go with the project, but I knew it would have to be something with a student's sense of place. I greatly enjoyed and appreciated all of my master's courses leading up to my capstone practicum and project and find pieces of each in my final project. I especially found valuable the two field-based courses I took the summer of 2018 - the Environment and Society course and the Biomes course. The idea of place and who tells the story was a key takeaway from the Environment and Society course as we traveled around Minneapolis and St. Paul, MN. Each location can be explained in many different ways depending on the perspective and background knowledge of the land's story teller. In the Biomes course the idea of place spread out further and appreciating and understanding specifics and generalities of where one is was ever present. Places change over time due to both natural and human interference. After taking these two classes, I knew I wanted to do something based on what I learned from each of them.

My writing and researching skills greatly improved in completing my capstone. Many editors noticed odd tendencies in my grammar that I never noticed and now I am trying to train my brain not to make these simple mistakes. I also struggled to write a little each day and found better luck chunking out a longer time on a day so that I could add a few details in the next few days. As I learned how to navigate different online databases and book resources, I learned simple tricks to narrow my search to find what I found most useful.

In learning more about the Understanding by Design unit framework, I struggled for a while to determine how to use it in a way that was concrete. I ended up greatly

enjoying making my unit plan and constantly editing it as I realized what was left out of my first draft. It was extremely helpful in putting my thoughts together before I came up with my individual lesson plans.

Revisiting my Literature Review

During my capstone practicum course I read many resources on place-based education (PBE), geomorphology, Minnesota geology and the present and upcoming Minnesota Academic Science Standards. Key learnings will be discussed about each part of my literature review in this section.

I spent the most time researching PBE which was a new form of education for me name-wise, but I had already been using some aspects of it in my teaching career thus far. PBE involves students developing a sense of place, building connections to the land and community and learning the cultural history of the area. In my teaching I already was helping students understand their place in the water cycle and in climate change, but not in how they were connected to the local landscape. I also did not have students interview people to build their cultural knowledge and learn multiple perspectives about an area. Local cultural history can be combined with the geology to provide students an opportunity to get a deeper understanding of a place (Cook, 2018). In my project I have students interview at least one person in their community who has lived there for a long period of time and has perhaps seen changes to the landscape over time.

Semken et al. (2017) describe PBE as a model of teaching and learning that is context-rich and transdisciplinary, where students develop a relationship to a place through experiences helping them build meaning and personal attachments to a location. I

used this definition of PBE in constructing my unit plan and lessons. Semken et al. (2017) also list the learning outcomes for PBE as the scientific knowledge of the place, diverse meanings, authentic experiences, sustainable practices and the development of a sense of place. These outcomes were my main goals in my unit plan. Lowenstein et al. (2018) separate PBE into three sections: inquiry-based instruction, connection to place, and informed civic engagement. Place-based inquiry involves student investigation, teacher guidance and students finding environmental issues in their community to which solutions could be suggested. Each of these aspects I included in my project.

Building off of the environmental theme, I wanted students to value their local natural area and want to protect it. Russ, Peters, Krasny, and Stedman (2015) explain how developing an ecological place meaning comes from understanding how parts of an ecosystem are seen as valuable and important parts of a place - which can lead people to take better care of an area. At the end of the project, students are to find an environmental issue and come up with a solution to work towards solving it.

My second main section in my literature review was on landscape interpretation skills and geomorphology. Geomorphology is the study of Earth surface processes, landforms and geologic history and also parts of physics, chemistry and biology (Reusser, Corbett & Bierman, 2012). One way for students to show what they understand in science is by making a concept sketch. Concept sketches are organized and labeled diagrams demonstrating the formation, processes and interactions between parts of a scientific concept (Reusser, Corbett, & Bierman, 2012). I have students going outside on the first

day to make initial observations and then toward the end of the unit to synthesize their new understandings, combining what they observe outside with the classroom learning.

Another way to interpret the landscape is by reading maps. In my curriculum I have students use topographic maps and Google Earth. Topographic maps display the shape and elevations of landforms using contour lines, which represent three-dimensional landscapes on a two-dimensional surface (Richardson, Sammons, & Delparte, 2017). Google Earth takes maps one step further and using Google Earth has been shown to improve students' topographic map reading skills over just using paper topographic maps due to students using the 3D visualization feature to improve their spatial thinking (Hus, Tsai, & Chen, 2018). I have students start with topographic maps of the past and present and then transition to Google Earth to add that vital extra layer of interpretation.

For my third section on the geology and biomes of Minnesota, I realized that I needed to go deeper into the connection between the two concepts. For example: the biome my school is in is the Deciduous Forest, with the forest type of Maple-Basswood. The trees in this forest type are very sensitive to fire and its boundaries were controlled by fire in the past not being able to cross rivers, lakes or rough topography (Wendt, Coffin, Marschner, University of Minnesota, & Natural Heritage Program, 1988). This rough topography is due to the glacial deposits of landforms such as hilly moraines. Connections like these will help students see how geology can influence the biology.

My final section in my literature review was on the Minnesota Academic Standards in Science. The present standards were approved in 2009 and are in the middle of a review. If the newest draft is approved, they will fully be implemented in the

2023-2024 school year with a gradual implementation to switch many of the sixth and eighth grade standards (Minnesota Department of Education, 2019c). The two benchmarks I am using in my curriculum project from the new set of standards are: “construct an argument, supported by evidence, for how geoscience processes have changed Earth's surface at varying time and spatial scales; [and] apply scientific principles to design a method for monitoring and minimizing a human impact on the environment (Minnesota Department of Education, 2019c).

Going back and rereading my literature review and connecting it back to my curriculum project, I realized that spent less time than I expected in my project on Minnesota geology in general and really focused on the last 2 million years of geologic history because the glaciers greatly influenced the landscape of Minnesota. I am not saying that the rest of the geology is not important, but my unit would be likely twice as long if I were to have included a lot more in the story. As most of Minnesota is covered in glacial deposits, it made sense to me to have the main scientific concepts be on glacial landforms in the Minnesota landscape.

Implications

The intent of this curriculum is for students to develop a better understanding of where they live geologically and culturally, who lives and lived in their area, how to be a more integrated part in the community by building relationships with community members, proposing a solution to an environmental issue and hopefully implementing it. These skills can be transferred to wherever they live and travel to in the future. In

increasing a desire to develop a sense of place, students can feel more connected to an area locally, and perhaps the world globally.

One big sticking point in this exact timing of my curriculum project are the likely adoption of the Minnesota Academic Standards in Science. For the next few years, teachers will be looking at the present and proposed new standards in developing their curriculum. The new version is due to be approved soon and if put in place, many science teachers might be switching either the grade level of students they teach or the core subject they teach and stay with their current grade level. Many sixth and eighth grade content standards are due to switch so teachers might be looking for easy to use curriculum. I hope in having my lessons include both sets of standards, teachers will be more likely to use them.

Also in regards to the standards is the fact that there are not many Minnesota environmental education standards in existence. The new set of standards does include more specific expectations, but it still doesn't feel like enough. Policies might need to be changed to increase the number of environmental education standards and the depth at which they are required.

Limitations

My capstone project has a few limitations. My curriculum is specific to Minnesota geology and I used local examples in the lesson plans. If a teacher would like to use this project and teaches in another state, they will have to find different local resources to supplement the lesson plans. A second limitation is that there are not many standards used in this set of a three week unit so teachers might not be able to use the full

set due to the large amount of standards students must know and understand by the end of a school year. A third limitation is that these lessons are made for middle school aged students so teachers in a different age setting will have to adapt them as necessary. A few final limitations might be extreme weather when trying to go outside and not having the necessary materials for the labs. Adjustments may need to be made depending on these variables.

Mine and Others' Future Work

After I implement this project with my students, I plan to evaluate and reflect on what went well in students developing their understanding and what could be improved. I will then make the necessary changes to my curriculum. I will share my results with others who I know are using parts or all of my project so they can benefit from my trial run.

As I mentioned in my literature review revisiting section, what I am missing in my project is more of a focus on the rest of the Minnesota geology story prior to 2 million years ago. I have pieces touched on it in my project, especially in the "What's under my home?" lesson, but someone else interested in developing a full picture of Minnesota geology could go deeper. They could perhaps choose a region with more bedrock exposed at the surface, like Duluth, MN or the Minnesota River Valley and use the process of place-based education to build out a concise unit.

An extension to my curriculum project would be for students to take a field trip off site to get a better experience at a specific glacial landform or biome. There are places

close to my school but with buses being as expensive as they are and daily schedules hard to modify, these might have to be either virtual or optional weekend field trips.

Benefits to Students and Teachers

This curriculum unit project is important and useful because it will help students develop their sense of place and connect to the natural landscape and their community. This is a skill that they can keep and use wherever they live and will help them be more involved in learning the scientific and cultural aspects of their area. This project is also beneficial because students are learning about their local surroundings, which makes it relevant and more engaging than the more traditional lecture and notes setting. In being more real-world, it becomes more applicable to students and hopefully more fun.

My project will benefit teachers because it is a set of three weeks worth of curriculum that is already made. Teachers can use all or part of this unit and edit it how they deem fit based on their own local surroundings. My hope is more students and teachers beyond just myself and my students will be able to use this project.

Chapter Summary

In chapter four I reviewed my overall conclusions to my capstone experience. I discussed what I learned during my time in all my Master's courses, what I learned about myself as a student, I touched on all my sections in my literature review focusing most greatly on what I learned about place-based education, what my project will hopefully do for students, how the Minnesota State Academic standards in Science are still in the middle of review, a few limitations and ideas for future work and how my project will be useful to students and teachers.

When one has the tools to read a landscape and learn its story, one can develop a sense of place and connection back to the land. When one can appreciate and understand how an area formed and changed, one can feel proud of their accomplishments and a part of that landscape. When one is able to see how the land is and was, one can help to decide how it should be in the future and do their best to take care of it. As Agassiz (1866) said, the world is really a geologist's puzzle and one must determine how the pieces fit and see the connected picture to glean the story.

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