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The Benefits Of Advancing The Next Generation Science Standards In The Elementary Grades

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THE BENEFITS OF ADVANCING THE NEXT GENERATION SCIENCE

STANDARDS IN THE ELEMENTARY GRADES

by

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DEDICATION

To my wife, for her constant encouragement and support. Thank you to my grandfather, Arvid Dittbenner, for reminding me that I didn't have to know it all, I just had to listen. To Dr. Deb Sheffer, for encouraging me to be more than a short-call substitute. Thanks to the Capstone Committee and to my classmates. Collaboration, in any setting, is the stuff dreams are made of.

“When I see the sea again

has the sea seen me or hasn’t it seen me?

Why the waves ask me

The same that I ask them?

And why do they hit the rock

With such a futile enthusiasm?

Don’t they get tired of repeating

their declaration to the sand?”

-Pablo Neruda-

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Chapter One

Introduction

In 1953, a man and wife along with their 5-year old daughter, traveled from Staples, Minnesota to the tiny bedroom community of Wayzata. At Staples High School he was a general science teacher, a coach and member of the community. As a part of the Wayzata Public School district, he would do the same for the next thirty four years. He taught with passion and a poetic pluck that would cause students to remember him and his lessons decades later. It was because of his passion and desire to make science interesting that students and faculty could hear him tell tall tales of meteorological events that could pick a building up off its foundation or turn a cow inside-out. Tales not meant to be taken literally, rather stories to engage the scientific mind and done only with the intent to capture the imagination of the students in his class. He was passionate about models, sand tables, dioramas, displays and the kinds of physical manipulatives that put science in the hands of the students. This man was Arvid Dittbenner, my grandfather.

I grew up around science. More than remanded textbooks, discarded chemistry sets, and second-hand dioramas, I grew up with the understanding that scientific knowledge is a good thing. At a very young age I was taught the true nature of clouds. By the age of five I was exposed to and understood words such as plate tectonics, epoch, era, genus, species and brachiopod. We would build model rockets in the summertime, launching them in the street and jumping onto bicycles to chase after them, often to find them stuck in the trees. My grandparents had a pool in their backyard, and rather than hurry me off to entertain myself elsewhere, I was invited to watch and participate in the mixing and adding of the chemicals. I was supervised around science, not infantilized. I was taught that you didn't maliciously step on bugs, not as an edict on morality, but the notion that it might be something else's dinner. This went hand-in-hand with the notion that you didn't kill spiders because the only reason you have spiders in your house is because they have something to eat! These were my first lessons in earth science, astronomy, chemistry and biology. Make no mistake, in no way did this make me a scientific wunderkind. It did, however, educate me. It let me know that there were answers to my questions. That my questions were ok to ask and asking them didn't make me dumb, it made me curious. It's in this analogy about my own foundations in science learning, that we have to decide, when and at what age are we going to start making science a priority in the classroom? Throughout the twentieth century and into the present, this country has used science education like a campaign promise, talking a good game, but failing to deliver in the end. From the Cold War to today, science education has been the pie crust promise: Easily made, easily broken.

In the late 1950s the United States and the Soviet Union were in the middle of the Cold War. The Soviets were winning every technological battle: First into space, first signal from space, first human into space. If we built two nuclear bombs, they built three. This nationalistic game of one-upmanship didn't spare our schools. They were the enemy, after all, and we would all have to do our part if we were going to win. The federal government responded to public demand, and in September of 1958, the congress passed the National Defense Education Act (NDEA). This was a wholesale funding, providing loans and grants for any science-related field of endeavor or study, rather than drafting citizens to fight in the armed forces. This is remarkable as it was no longer for the citizenry to learn at-will, but for the first time in the history of the country, an act of

Congress was established to learn for the good of the country (Congressional Digest, 1960). It's also of note that the financial endowment under this act covered all aspects of education and training so long as it was in the name of national defense. This meant that the federal government was going to take a financial interest in anyone going into any kind of technological field including radio, television or movies. This, in essence, is the United States' first foray into Science, Technology, Engineering and Mathematic or STEM curriculum.

Fast-forward twenty five years, to 1983. While the Cold War continued on, the Soviet Union was less than a decade from collapse. The United States overcame early failures in its space program of being runner up to putting the first primate, man and woman into space. It eventually and unofficially won the Space Race by landing on the moon. The U.S. had spent the latter half of the 1960s and the first half of the 1970s fighting in Vietnam. The Department of Education and the public in general, shifted their focus to civil rights and equality. The threat of Soviet Communism no longer drove the engine of education. As the country moved into the 1980s, a societal shift took place and the peace and love generation settled down and got married. The nation was gripped by a post-Vietnam recession, fueled by rising gas prices, inflation, and growing overseas trade deficit. These are serious problems for a nation, and serious problems can either be solved or the blame can be passed along. In this case, the Ronald Reagan administration commissioned a group from private businesses, government, and education and what they submitted to the public was the blame and cure-all in the form of a report, 1983's *A Nation At Risk: The imperative for educational reform*. This, in essence, was NDEA-style propaganda from the Reagan administration, but playing the role of the Soviet

Communists in this reincarnation was our ability to compete with the foreign business interests of other emerging countries. *A Nation at Risk* was going to be the government-authored compendium that was going to solve all of the nation's educational issues.

As the country continued to move through the 1980s STEM (Science, Technology, Engineering and Mathematics) was born and, while one would think that STEM might be the curricular answer to everyone's prayers, it has yet to catch on as a national priority in education. Yes, the argument can be made that there are some school districts and schools that are doing some great work incorporating STEM as a backbone of their curriculum. However, debates over whether or not to add an A (for art) to the acronym and call it STEAM, lends credence that this is not a move to a more scientific learning environment and is not the true nature of this curriculum. As educators and curricular specialists we find ourselves not really investing in STEM, instead, going through the motions and appearing to innovate. I'm reminded of an adage regarding sticking feathers in one's pants and demanding to be called a chicken.

The Soviet Union no longer exists. The 1980s are now referred to by some as *the good ol'days,* although I would argue that from a fashion standpoint alone. Gone are the Cold War and the nationalistic sense that another nation is out to get the United States. So why would I give a sixty-three year overview of science education in America? We are into the third decade of the twenty-first century. As a nation, we are supposed to be enlightened. We are supposed to be innovating. If you simplify it to a level your elementary-aged self would understand, according to the cartoon show *The Jetsons,* we're supposed to have robot maids and rocket cars that fold into briefcases. It's the year

2021 and we are still by and large treating science education like it's the cause-of and solution-to all of life's problems. We largely dismiss it within the walls of our own schoolhouses as an elective or something we should try to teach after we teach our lessons on the three R's. Some of us avoid it like the plague because of our own bad experiences as science students. Others avoid teaching it because they don't know much about science and are afraid to not know the answer in front of their students. Perhaps it's because we live in a country where a cross-section of its citizens view science as no different than a religion. Something to believe in if you choose to, rather than a discipline, rooted in fact.

Whatever the case may be, we are not making science education a priority in this country. We are producing students who, by the time they reach middle school, are no longer interested in, or no longer prioritize science education in their own academic careers. This is a shame. With our resources, we should be producing scientists or, at the very least, students with strong backgrounds in science foundations like the world has never seen before. I contend that there is a better way to teach science. A better way to create scientific-minded learners. A way to have students reach the developmental and cognitive levels in which they can begin to process next level functioning in scientific exploration in the classroom while not having lost their child-like wondering and questioning of the science that surrounds them. It doesn't involve tearing up our current curriculum and it doesn't involve hiring someone's grandfather so our students can vacuum his pool or count the spiders in his basement.

For about the last ten years the National Resource Council, the National Science Teachers Association, along with a couple of other councils, associations and

Departments of Education of half the states in the country, have been working on an approach to changing how our standards are taught. They are calling these changes *Next Generation Science Standards* or NGSS. Plans are already in place in this state to mandate implementation of these standards by the 2024 school year. At first glance this re-shuffle of existing standards into a new package gives me the sinking feeling that if something is not done in conjunction with the implementation of NGSS, then we are doing nothing more than putting new paint on an old car. We will be committing the same sins as the past efforts of the NDEA, *A Nation at Risk* and STEM curriculum. I contend there is a way to help NGSS gain broad acceptance and success by asking the question: *What are the benefits of advancing Next Generation Science standards in the elementary grades*? I don't feel that NGSS will be successful just by re-wrapping the science curriculum in a new package of phenomena-based questioning. We have an opportunity to use the natural curiosity of young minds to entrench this new approach to looking at the standards at a younger age and change the paradigm of lack of interest as they age. We have a whole nation filled with five and six-year-olds who are already asking questions every day. Why not put the learning in their hands from the first day? If scientific thought is the way it's always been and it's all our learners ever know, I feel more of them will stick with science as a field of study later in their education.

I believe that my capstone project will show that there's no need to change the NGSS standards, instead just advance them or move up the time table within the elementary grades. In the following chapters I will provide modeling on what such an advancement might look like at the elementary level. I will discuss the hurdles and pitfalls of a curriculum change of this nature, presenting the benefits to educators and students alike.

I will discuss, in theory, what can be done in the upper grades if a school makes this shift in the curriculum. It's my hope that the result of this research will show that we have the audience, the curriculum, and all of the tools that we need. What is needed now is to finally take the step, make science education a priority and teach our students from day one that it is ok to ask questions and doing so is at the heart of scientific thinking.

Chapter Two

Literature Review

Introduction

When asking *what are the benefits of advancing the Next Generation Science Standards (NGSS) in the elementary grades*, one must first ask, what are the benefits of science education in the first place? From the perspective of science as a viable branch of curriculum, one need only look to the multiple paradigm shifts in science education in the twentieth and early twenty-first century to see how science and science curriculum is viewed by legislators and educators as a vehicle for change and for enrichment of pedagogy. As Kliebard (2002) put it, "there already existed a pale cast of pessimism as to whether the proposed innovative practices would actually make their way into schools and, if they did, whether they would endure" (Kliebard, p.126-127). In this chapter evidence will be presented that will address the hurdles that face the implementation of advancing these science standards. These hurdles include those found in curriculum development as well as past curriculum policies. The struggle with NGSS recommendations and the struggle with teacher belief and fears of content competencies. This chapter will outline how other nations organize science curriculum and compare that to the current domestic models. The literature review will show what modeling such a paradigm shift would look like and the potential outcomes of this modeling.

Hurdles

In the process of answering the question of *what are the benefits of advancing the NGSS standards into the elementary grades*, one must consider the fact that there are certain hurdles that exist, preventing this from being a viable consideration in modern science curriculum. These hurdles could be internal or external within the constructs of a school, its district, the district's regional or federal governing bodies. This is true in the state of Minnesota, where NGSS standards have yet to be put in place as the standards do not yet include all of the state government mandated assessment components (education.mn.gov, n.d.). Hurdles at any one of these levels could account for such curricula not already being in place.

Curricular Development

Curricular development is a process and sometimes the biggest obstacles in the path of change in this process are the agents of change. In Minnesota, for example, the Department of Education is headed by a commissioner. The commissioner is able to introduce recommendations to changes in curriculum, but without legislative action or change from the state capitol, policy would not change. A state’s Education Commissioner having little or no direct executive power is not out of the ordinary, but in a state like Minnesota, which was among the first of the states to jump on board and become designated a “lead state” by the NGSS framers, it has yet to officially adopt these NGSS standards; whereas other states are already implementing them (nextgenscience.org, n.d.). State standards are reviewed and revised on a schedule approved by the Minnesota State Legislature on a ten-year cycle. The implementation year for each content area’s new standards is identified during the rulemaking process, and takes into account multiple considerations, including the degree of revisions and whether complimentary statewide assessment must be developed (education.mn.gov, n.d.). In this case, the last review cycle for science standards was the school year 2018-2019. With the NGSS standards slated to be implemented in Minnesota by the end of 2024, there would be no review of its outcomes or success prior to 2028-2029 as a part of the ten-year curriculum review cycle (education.mn.gov, n.d.). This is an example of how a state legislative component is a hurdle that must be overcome for NGSS, with or without enhancements, to be implemented into law as the state's science curriculum.

Any new curriculum directive, having cleared the hurdles of the state legislature, is then pushed out to the independent school districts as an adopted set of standards. Districts are required to offer all standards. Most of the state standards are achieved through the benchmarks. Schools must offer and students must achieve all benchmarks for an academic standard to satisfactorily complete that standard. Districts are required to have plans for instruction and achievement for all students (Minn. Stat. Section 120B.011, subd. 2(b)).

There will inevitably be budget constraints within the individual school districts for purchasing new curriculum. The builders of the NGSS curriculum are promoting one of its high points is that this is a paradigm shift in how curriculum is taught, rather than the specific curriculum taught (National Resource Council, 2015). It has been encouraged by many involved that districts shouldn't take on new curriculum materials as the NGSS has yet to be implemented universally. Instead, a district should look to allocate its finances to new and aligned curricular materials and instead should look at its existing curriculum before implementation or purchase of new materials (National Resource Council, 2015).

Past Curriculum Policies

Decision makers at the state level are following the basic recommendations of the U.S. Department of Education's guidelines on science curriculum. States have been doing this since the late 1950's during the time of the *National Defense Education Act*

(NDEA). The NDEA was a Cold War era response to co-opt the educational system in the name of national defense. While not curricular in nature, it provided financial backing to anyone interested in pursuing a technological-based education (Congressional Digest, 1960). In the 1980s, during the Ronald Reagan administration, the National Commission on Excellence in Education, published a 70 page document titled: *A Nation At Risk: the imperative for educational reform*. In it, the Regan administration claimed that the country was at war, threatened by advancing Foreign Trade. Furthermore, the United States educational system was to blame for it (United States, 1983). A laundry list of problems were included in *A Nation at Risk*, but there were no long-term curative solutions, just additional testing and penalization schemes for schools that didn't meet government standards. In fact, USA Today Magazine pointed out that: "Twenty years after the historic '*A Nation At Risk*' report set off a nearly continuous wave of education reform, most of those goals were never met" (USA Today Magazine, 2003, p.1). In the early 1990s, *Project Lead The Way* came from a private-sector need for qualified applicants from science, technology, engineering and mathematical backgrounds (Starobin et al., 2013). The Next Generation of Science Standards will have to be more than an educational funding bill or an administration's policy directive in order to distinguish itself from the curricular reforms that have come before it. The NDEA, *A Nation At Risk* and *Project Lead The Way* as well as the Next Generation of Science Standards are all attempts over the last half century to enact sweeping changes that would seek to revolutionize and innovate science education, however, this has yet to happen on any broad scale.

NGSS Curriculum Recommendations

The framers of the NGSS have made recommendations during its construction regarding its implementation such as:

- Communicating and supporting a vision for instructional design.
- Supporting teachers in making incremental instructional changes to improve instruction.
- Developing a classroom culture that supports the new vision of NGSS.
- Making assessment part of the instruction.
- Start at the top of the leadership chain and work down from there.
- Developing comprehensive, multi-year Professional Development plans.
- Basing the design of the aforementioned Professional Development on best practices.
- Cultivating partnerships with entities outside of the school for Professional Development.
- Refrain from replacing existing materials and/or purchasing new ones.
- Make decisions on scope and sequencing.
- Be critical of new curricular materials as they become available.
- Make sure the Curriculum targets are clear.
- Create new assessment and monitoring for targets.
- Aid teachers in creating formative assessments.
- Collaborate within and outside the school.
- Network within and outside the school.

- Partner with the private sector and others with a vested interest in science-based outcomes for graduates.
- Ensure state and local policies adhere to the goals of implementing NGSS.
- Create timetables and monitoring tools that are practical, realistic and understood.
- Use the NGSS framework to push teacher preparation.
- Communicate District plans for the NGSS with the community-at-large.

(National Resource Council, 2015, p.2-8)

There are twenty-one bullet points and they are filled with words like collaborate, communicate, partner, design, develop and construct. All of these are intended to inspire and motivate the reader into engaging with and implementing this new curriculum. These action words tangentially relate to an important hurdle to implementing NGSS curriculum in the classroom at any level: the teachers themselves.

Teacher Belief and Content Knowledge

Teacher belief and faith in their own competencies factor in when implementing a new curriculum. As Kagan put it, “a teacher’s beliefs usually reflect the actual nature of the instruction the teacher provides to students” (Kagan, 1992, p. 73). The NGSS Standards are grounded in the belief that all students can and should be scientifically literate (education.mn.gov. n.d.). Teachers, regardless of their science background or scientific literacy, must be willing to engage in a new curriculum in order for it to be effective. Kagan went on to say that “science teachers who have conceptual understandings of their fields tend to emphasize conceptual explanations and to modify textbooks, whereas teachers with superficial understandings tend to lean heavily on prepared texts, rarely modifying them” (Kagan, 1992, p. 73). This is not correlative in tracking the content knowledge for science instruction. Little data exists for tracking science content knowledge in the practicing teacher. Most of the data lies in the sampling of the pre service teacher (Diamond, 2014). Standards and benchmarks, in general, are met with minimal effort and innovation. Oftentimes the student's fear of being good at science is mirrored by the instructor's fear of not being good at teaching science (Zubryzcki, 2016). The bullet points listed above are all hurdles that one would need to address with the classroom teacher and get them to commit in regards to the new curriculum before moving ahead with implementation of NGSS standards. A teacher's pedagogical strength or weakness would factor into the efficacy of new curriculum implementation. The struggle to adopt a new curriculum is not exclusive to the United States. In discussing a new national curriculum in England, Ashcroft and Palacio (2002) pointed out that "The Department for Education (DFE) does not generally produce its National Curriculum material in a form that makes it easy or enjoyable to read, although this version is an improvement on previous ones. You may have to put a great deal of effort into understanding and interpreting earlier versions of the National Curriculum and be unenthusiastic about starting this process again" (Ashcroft and Palacio, 2002, p. 3).

Content knowledge cannot be overlooked as a hurdle to implementing a new curriculum or the delivery of an existing one. This NGSS-based curriculum, whether implemented as written or used as a foundational guide with a state's own departmental requirements, as in the state of Minnesota, constitutes a paradigm shift that educators will have to adapt to (education.mn.gov, 2019). However, the foundational aspects of the NGSS curriculum are designed to overcome these hurdles. As Colson and Colson (2016) pointed out, “the six most powerful instructional words in the NGSS-friendly classroom are, ‘I don’t know; let’s find out’” (Colson & Colson, 2016, p.53).

How Other Nations Implement Science Curriculum

The NGSS standards are the next generation of science curriculum, and states have already begun to implement the standards either as written or in hybrid with benchmarks they deem important to their curriculum (nextgenscience.org, n.d.). Before we can question the benefits of advancing NGSS standards in the elementary grades while the NGSS is still in its infancy, it is necessary to review how other nations treat science curriculum. How schools in the United States adjust their curriculum, in this instance adjusting it before it’s been implemented, may be aided by the work of other nations. The work of allies and neighbors can reflect on what schools in the United States are doing and what schools are going to do in the future regarding how they handle science curriculum.

Not unlike mathematics, science education has a universality to it. The fact that science as a discipline is an exploration and examination of the physical world around us. It is not subject to varying languages, perspectives on historical events, sociological and political stances that can vary from country to country. The sciences do not waiver based on geo-political lines on a map. Therefore, how other nations teach their children science at the same time can be used as a touchstone or benchmark of how the United States is compared to the rest of the world. In looking into curriculum maps from other nations, one must look for variatiations of similar curriculum within the grade levels. If one could show that other countries were teaching similar standards to those in the United States, but introducing them at various grade levels, it would indicate an opportunity for advancing NGSS standards in the elementary grades within a state's curricular construct.

Canada

In looking at Canada's curricular structure, some supportive trends begin to appear. For some time now, Canada has outpaced the United States in benchmarking its literacy, mathematics and science scores, despite the United States spending more on education than any other developed nation on the planet (cnbc.com, 2018). Canada, due to a wide series of reforms in the past two decades, has emerged as an educational leader in international assessment rankings (ncee.org, n.d.). A country composed of ten provinces and three territories, Canada is a nation that has no national system or federal department of education (Canada.ca, n.d.). Curriculum development and final decision making is left to the individual provinces and territories. In reviewing how they could be so successful without multi-tiered oversight, a hallmark of most public institutions in the United States, the research takes a look at four of the most populous provinces and a less populous one, Nova Scotia. This review of Canadian provinces continues to bring the question of advancing science curriculum in the primary grades into focus. In taking a look at the science curriculum maps of the provinces of British Columbia, Manitoba, Ontario, Quebec and Nova Scotia, one can see that, while not taught in the same order, the same or similar standards are covered during the elementary level of instruction. This component of the literature review begins to support the notion that timing and placement of curriculum will take a back seat to pedagogy and content. It will begin to answer the question of the benefits of advancing the Next Generation Science Standards (NGSS) in the elementary grades. To use British Columbia as a starting point only based in its geographic locale, narrative points of their curriculum map looks like this:

Kindergarten

- Plant and animal features
- Matter
- Motion
- Seasonal changes

First Grade

- Living adaptability
- Matter uses
- Light and sound properties
- Patterns and cycles

Second Grade

- Life cycle adaptations
- Physical and chemical material changes
- Forces that influence the motion of an object
- Water is essential for all living things

Third Grade

- Biodiversity in ecosystems
- Composition of matter (particles)
- Production and transfer of thermal energy
- How wind, water and ice change the landscape

Fourth Grade

- How living things respond to their environment
- Matter has mass, takes up space, and can change
- Energy can be transferred
- Earth and moon rotations cause patterns and changes to living and non-living systems

Fifth Grade

- Multi-cell organisms have systems that allow them to survive
- Solutions are homogeneous
- Machines are devices that transfer force and energy
- Earth materials (rock cycle)

(edu.gov.bc.ca, n.d.)

While this is just a bulleted list of British Columbia's elementary science curriculum, patterns begin to emerge that foster support of the importance of the curriculum taught versus when it is taught in supporting *the benefits of advancing the Next Generation Science Standards in the elementary grades*. The next provincial curriculum reviewed was that of Manitoba. Manitoba's curriculum is fairly comparable to that of British Columbia in Kindergarten through the second grade, with some noted differences. Sound, for example, introduced in the first grade in British Columbia, isn't introduced until the fourth grade in Manitoba schools. Rocks, minerals and the rock cycle is a fifth grade component in British Columbia, and introduced a year earlier in Manitoba (edu.gov.mb.ca, n.d.). In Ontario, the standards are similar as well. However, rocks and minerals are taught a year later in British Columbia. Biodiversity, taught in the third grade in British Columbia, isn't done so until the sixth grade in Ontario (edu.gov.on.ca, n.d.). In Quebec, the schools follow a model comparable to that taught in France. This is understandable as they have a rich historical context with French that settled Eastern Canada. In Quebec, as in France, the elementary grades are taught in cycles, one through three. The components of these cycles are sectioned into three categories: Material World, Earth/Space and Living Things. Their subcategories are as follows:

- Matter
- Energy
- Forces and motion
- Systems and interactions
- Techniques and instrumentation
- Appropriate language (taught throughout all cycles)

(education.gouv.qc.ca , n.d.)

The instructional cycles of scientific curriculum in Quebec are comparable in grade-level and timing with the other Canadian Provinces. The last sample province is Nova Scotia. This province is in keeping with its neighbors to the west, with a couple of significant addendums. As we had seen before, sound and light aren't introduced until the fourth grade as it is in Manitoba. Rocks, minerals and the rock cycle are introduced during the fourth grade as well. Two things stuck out in my review of Nova Scotia's curriculum map. In the second grade, their standard on water being essential to all living organisms, which is consistent in grade standard with other provinces, is cross-culturally paired with the focus on its resident indegenous or First Nations people, the Mi'kmaq. (curriculum.novascotia.ca, n.d.) This is of note, as many school districts in the United

States, including Minnesota, have required cross-cultural learning components in their curriculum and here it is part of a standard in a Canadian province (education.mn.gov, .n.d.) The second note of interest in Nova Scotia's curriculum map is the introduction of modeling and questioning, a touch-point of the new NGSS curriculum. In this instance, the last three standards in the fifth grade curriculum ask students to construct, analyze and test an idea constructed by the student (curriculum.novascotia.ca, 2019).

The cross section of information about Canada is interesting. According to 2018 data, Canada was thirty-eighth globally in population and one hundred twenty second in growth (worldpopulationreview.com, n.d.). It is a country where each province has its own Ministry of Education, which is run by a Minister of Education appointed by an elected Prime Minister. The Ministry sets standards, determines curricula and allots funding to the state schools in their province, as well as oversees the teacher certification process and the provision of school support services such as transportation, health and food services and libraries (ncee.org, n.d.). Provinces typically organize their school systems around locally elected school boards. Local school boards are elected bodies and work in conjunction with the provincial government. School boards are responsible for all major hiring and personnel decisions, from the chief superintendent to the teachers. They also set annual budgets and may have some oversight on new programs and policies. Some of the provinces, such as Alberta and Ontario, provide public funding to a sizable sector of religious schools, mostly Catholic schools (ncee.org, n.d.). Canada has no centralized ministry or department of education, yet it is outpacing the United States in its educational scores and graduation rates per capita. While a nation's graduation rates or global ranking is not in question here, the takeaway is that time and time again in looking at the Canadian provincial curriculum models, standards are being introduced at different grade levels, lending credence to the notion that one could advance curriculum standards here in the United States, playing on the importance of standards inclusion over when standards are introduced. Once a state has rolled out the NGSS standards, we should, in theory, be able to advance them with a new model.

Great Britain

Another national profile reviewed was England. Though Great Britain established its first national curriculum in 1944 by the way of a national education policy that provided for an education for children to fifteen years of age, its educational system remained largely unchanged up to the 1980s (Ashcroft and Palacio, 2002). In the late 1980s, lobbyists and politicians fostered their own ideals and goals for public education in Britain and introduced the *1988 Education Act* (Ashcroft and Palacio, 2002). With multiple groups and decision-makers having input into what was going to be a part of this curricular shift in Britain, as Ashcroft and Palacio put it, "a number of important, but non subject specific, issues were absent from the proposed curriculum. This led to the notion of the cross-curriculum theme, the cross-curriculum dimension, and the cross-curriculum skill" (2002, p. 7). This advancement in their unified curriculum laid the groundwork for what their curriculum model looks like today. Today, their first six years of primary science education looks like this:

Year One

- Working Scientifically
- Plants
- Animals, including humans

- Matter
- Seasonal changes

Year Two

- Living things and their habitats
- Plants
- Animals, including humans
- Uses of everyday materials

Year Three

- Plants
- Animals, including humans
- Rocks
- Light
- Forces and magnets

Year Four

- Living things and their habitats
- Animals, including humans
- States of matter
- Sound
- Electricity

Year Five

- Living things and their habitats
- Animals, including humans

- Properties and changes of materials
- Earth and space
- Forces

Year Six

- Living things and their habitats
- Animals, including humans
- Evolution and inheritance
- Light
- Electricity

(www.gov.uk, 2013)

The British model in scope and sequence is comparable curricularly to the U.S., Canada, and France in that it is comprehensive in the scientific fundamentals needed to expand on topics taught in the following year. It's curriculum content is in keeping with other developed nations around the world. England, for its part, falls more closely in relation to the United States in its global rankings on education and graduation. In contrast to the Canadian model and similar to that of the United States, England has a very structured Department for Education (www.gov.uk. n.d.). Again, the success or statistical rankings of any of these four allied countries is not the question at hand. In looking at these curriculum maps separately, there seems to be very little, if anything, in terms of curricular structure that would stand in the way of changing the curricular timetable to accommodate an advance of the NGSS standards in the elementary grades in this country.

Japan

After World War Two, the Empire of Japan was democratized and included a constitution. In their constitution it states, “All people shall have the right to receive an equal education corresponding to their ability, as provided by law” (mext.go.jp, n.d.). Their elementary science curriculum is similar to that of the other countries in this literature review with a notable exception. The fact that their elementary curriculum doesn’t include science until the third grade. While kindergarteners are introduced to the realities of their surroundings and their interactions with nature, formative curricular benchmarks don’t begin until later (mext.go.jp, n.d.). The Japanese elementary science curriculum map has two main categories, *Matter and Energy* and *Life/the Earth*. Its benchmark standards are laid out as follows:

Third Grade

- Object and weight
- Function of wind and force of rubber
- Properties of light
- Properties of magnets
- Pathways of electricity
- Insects and plants
- Observations of familiar environments
- Sun and ground

Fourth Grade

- Properties of air and water
- Metals, water and air temperature

- Functions of electricity
- The human body
- Seasons
- Weather
- Moon and Stars

Fifth Grade

- Dissolution of substances
- Movement and pendulums
- Electrical currents
- Germination, growth and fruition of plants
- Birth of animals
- Function of running water
- Weather Changes

Sixth Grade

- Mechanism of combustion
- Properties of aqueous solutions
- Levers
- Uses of electricity
- Structure and function of the human body
- Plant nutrition and water pathways
- Living things and their environments
- Formation and change of land
- Moon and Sun

(mext.go.jp, n.d.)

The Japanese model has similar benchmark standards to those discussed in the literature review. Not starting their science curriculum until the third grade supports the notion that standard introduction within a specific grade year can be flexible within a curricular construct.

Modeling and Outcomes

The hurdles involved in unpacking a new curriculum and potentially advancing standards in the elementary grades have been discussed. The research has looked at and viewed models of what other countries are doing and discussed the potential effects of moving these standards within the constraints of the elementary grades. One must now begin to think about what this modeling would look like and what could be potential outcomes. For this construct, a review of the Minnesota state curriculum map and the 2019 draft of the science standards that includes the NGSS components of science and engineering practices, cross-cutting concepts and disciplinary core ideas is required. These three main dimensions of the standards help to weave the strands and substrands into attainable benchmarks. As noted before, it has been recommended that implementation take place with limited changes to the curricular manipulatives and lesson materials. The components of these dimensions are:

Dimension 1: Science and Engineering Practices

This dimension focuses on the important practices used by scientists and engineers, which all students should learn to use with increasing sophistication over their years in school.

- Asking questions (for science) and defining problems (for engineering)

- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Dimension 2: Crosscutting Concepts

This dimension lists key concepts, or themes, which connect knowledge from the various disciplines of science and engineering into a coherent scientific view of the world.

- Patterns
- Cause and effect: mechanism and explanation
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter: flows, cycles, and conservation
- Structure and function
- Stability and change

Dimension 3: Disciplinary Core ideas

This dimension includes the core ideas from the physical sciences, life sciences and earth and space sciences. Engineering, technology, and applications of science are included to provide an understanding of the built world.

Physical Sciences (PS)

- PS 1: Matter and its interactions
- PS 2: Motion and stability: Forces and interactions
- PS 3: Energy
- PS 4: Waves and their applications in technologies for information transfer

Life Sciences (LS)

- LS 1: From molecules to organisms: Structures and processes
- LS 2: Ecosystems: Interactions, energy, and dynamics
- LS 3: Heredity: Inheritance and variation of traits
- LS 4: Biological Evolution: Unity and diversity

Earth and Space Sciences

- ESS 1: Earth's place in the universe
- ESS 2: Earth's systems
- ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science

- ETS 1: Engineering design
- ETS 2: Links among Engineering, Technology, Science and Society

(education.mn.gov, 2019)

The modeling that will be outlined will include a revised curriculum map detailing the state's benchmarks for grades Kindergarten through the Fifth grade.

Conclusion

To date, NGSS-based science standards have only been adopted in a handful of states. This curriculum has yet to be seen other than in draft form in most states. The phenomena-based learning of NGSS-based standards seeks to change the hearts and minds of students by bridging the gap between the wide-eyed wonderment of primary grade science learners and their cynical, older selves (National Resource Council, 2015). The research in this chapter provides evidence that there is little standing in the way of advancing the NGSS standards in the elementary grades. The benefits of combining and adding to the existing grade-level standards in order to advance the learning forward would create a space in the curriculum model in order to build in time for a year of inquiry in the fifth grade year. Time and space, perhaps, for a capstone-like project. Or for giving fifth graders time to demonstrate their acquired knowledge to date as well as preparing them for their state's comprehensive assessments. This adapted model is built for the natural phenomena-based inquiry method of NGSS standards, and the adoption and manipulation to accommodate this year of inquiry, in theory, should aid learners in engagement and striving to keep their interest in scientific learning as they move toward their secondary phase of public education. This is an intended outcome as was the initial construct of the NGSS standards (National Resource Council, 2015).

The literature has shown there are other countries like Canada, that have a working model. This is a model complete with graduation rates and science scores to back it up, without sweeping changes to curriculum (worldpopulationreview.com, n.d.). If educators are to base their teaching on these Next Generation Science Standards, they will need to get the buy-in of their fellow educators, administrators, elected officials and the general public to this new curriculum. To not do this in addition to advancing these standards, they would be left with yet another policy-filled curriculum that could fail to move the needle forward. The initial question was *what are the benefits of advancing the NGSS* *standards in the elementary grades*. In the following chapter, a model will begin to take shape that will show the potential to keep the elementary grade learner engaged in scientific inquiry and show the benefits of doing so.

Chapter Three

Methodology

Overview

What are the benefits of advancing the Next Generation Science Standards (NGSS) standards in the elementary grades? Chapter Three will show the benefits and outcomes of modifying the proposed curriculum map to accommodate a fifth grade year in which no new curriculum would be taught. This year without new benchmark standards could be an available time for independent learning, remediation of prerequisite science skills and vocabulary or perhaps a capstone-like year of inquiry for the students transitioning into secondary settings. This shift was put into a structured map. Maps showing the difference between the planned course of instruction in science in the state of Minnesota as well as the amended curriculum map were included. The amended map was provided for those interested in implementation. Once the amended map was laid out for implementation, even if only in theory, this chapter also detailed potential uses for the space created by advancing the NGSS standards in the elementary grades. This project showed those potential benefits while laying the groundwork for implementation of NGSS standards as a viable curricular model. This shift in the curriculum, combined with the use of this additional learning time, will aid in achieving the goals of its creators by presenting "a vision of science and engineering learning designed to bring these subjects alive for all students, emphasizing the satisfaction of pursuing compelling questions and the joy of discovery and invention." (National Resource Council, 2015, p. 9).

Framework

The framework of this project is rooted in decades of science curriculum in the United States. The framers of this new curriculum, like those before them, are attempting to prioritize science curriculum as an essential part of a student's education. From the time of the *National Defense Education Act* (NDEA), the Federal government has demonstrated a willingness to dedicate funds to push science education reform (Congressional Review, 1960). Through the 1980s *A Nation at Risk* and *Project Lead the Way* in the 1990s, various groups have attempted to prioritize science education through financial and government-led reforms; the most recent prioritization of science curriculum is from the National Research Council and its *A Framework for K-12 Science Education*. The National Resource Council, or NRC, used three pieces of foundational framework for their standards in crafting *A Framework for K-12 Science Education*: science and engineering practices, cross-cutting concepts and core ideas. These served as the cornerstone of what would become NGSS science standards, the framework for this project. No two states will implement the NGSS science standards in the same manner. Individual states have concerns and values and will set their own curricular values accordingly.

For the framework of this project, I used the 2019 proposed curriculum map for the State of Minnesota, scheduled for district implementation by the 2024 school year. For its part, Minnesota's Department of Education adhered to its own legislative responsibility to include not only amended assessment requirements, but graduation requirements not specifically addressed in NGSS standards (education.mn.gov, n.d.). The Minnesota Department of Education also required an inclusion of cross-cultural learning, framed around the curriculum, so that all students would be able to "gather information about and communicate the methods used by various cultures, especially those of Minnesota American Indian Tribes and communities, to develop explanations of phenomena and design solutions to problems" (education.mn.gov, n.d.). Phenomena explanation and designing solutions are a part of the core concepts of the Next Generation of Science standards that this curriculum is adopted around. This inclusion of indigneous cultures is a component of the science curriculum that was also addressed in the Canadian model from Chapter Two, involving the literature in Nova Scotia's Provincial curriculum map (curriculum.novascotia.ca, n.d). This was one of the points that supported the notion that standards content was not grade exclusive or essential to *the benefits of advancing the NGSS standards in the elementary grades*.

The use of Minnesota's adoption of NGSS-aligned framework in the construction of this project showed that an adherence to NGSS core concepts of science and engineering practices, cross-cutting concepts and core ideas, in conjunction with moving these standards forward in the primary grades created a year for the fifth grade student without new science curriculum standards to learn. This gap year will be used as a cornerstone for the support of fostering the continuation of scientific learning in a student's secondary school career for younger learners, as well as opportunities for remediation if necessary and project-based inquiry for the student transitioning to a secondary school setting. It can also be used to stand as scaffolding for students early on in the implementation of NGSS standards, for their abbreviated time spent using the core concepts of these standards (National Resource Council, 2015). Once the new framework is built around these proposed standards, the benefits of this project came into view.

Building a curriculum map from existing standards and an existing map required some detailed thought. The purpose of the NGSS standard framework is to envelop the learner with science and engineering practices as well as cross-cutting concepts and core ideas (National Resource Council, 2015). So moving standards out of the fifth grade curriculum and simply cutting and pasting them into kindergarten through fourth grade would not work. There had to be some thought put into which standards are moved in order to adhere with the NGSS core concepts. The body of this project included the requirements to restructure a curriculum map, excluding the fifth grade from consideration. This would then allow individual districts or educational institutions to incorporate other instructional and translational science based curriculum for the fifth grade learner. Research suggested that this transitional age is the point at which the learner formulates their opinions on scientific learning (van Griethuijsen et al., 2014). The spirit of the initial foundational work of *A Framework for K-12 Science Education* was meant to bolster a favorable opinion of science education and inspire students to continue with science as a part of their daily life as scientists or as adults outside of scientific endeavors (National Resource Council, 2015). This change in the existing map could serve not only as an aid in the student's shift from an elementary school setting into that of a middle or secondary setting, but this scaffolded transition could allow them to continue with phenomena-based curriculum in an inquiry or independent learning setting.

Setting and audience

Whether or not an individual school district houses their elementary grade levels kindergarten through fourth or fifth grade, legislative oversight and a state's adherence to those statutes means that while there is a large audience for this project, implementation most likely would have to be incorporated into a department of education within the state before adoption and enactment could take place. While it is true there is a great deal of flexibility in a charter school and its ability to incorporate curriculum, pedagogy and practices within its framework (Shober et al. , 2006), I focused my attention on constructing this project with a public school district as the audience, using Minnesota's perspective 2019 Kindergarten through fifth grade science standard curriculum map as the sample. As the National Resource Council pointed out in their recommendations to implement these standards, rushing to replace curriculum isn't the point of efficacy or intent of the NGSS (National Resource Council, 2015). As previously mentioned, several curricular shifts throughout the twentieth century and into the new millennium have been considered. The *NDEA, A Nation at Risk and Project Lead the Wa*y all sought to invigorate the science curriculum in this country and inspire learners to participate in science-based curriculum. The prospective audience needs to include the learners themselves. Viewing this curricular shift from the standpoint of teacher, advocate, administrator or legislator, the goal remains the same: to create life-long science learners and to create the scaffolding of a gap in the learning to invigorate, inspire and inquire with the elementary student when they reach their most pivotal age in science learning (van Griethuijsen, et al., 2014).

Revised Curriculum Map and Project Description

Using the 2019 framework from the State of Minnesota's proposed K-12 academic standards as the curriculum map for the template, this project showed what the benefits of advancing the NGSS standards in the elementary grades can produce. There are seventy-three standards in Kindergarten through the fifth grade, fourteen of which are fifth grade standards. They are broken into: Strand, Substrand, Standard, Content Area and Benchmark. The three core standards from *A Framework for k-12 Science Education* are represented in the framework as dimensions. Dimension One, Science and Engineering Practices are taken from the Engineering Design Process of: Ask, Imagine, Plan, Create, Improve, with the additional steps of using mathematics and computational thinking, engaging in argument from evidence and obtaining, evaluating and communicating information (education.mn.gov, n.d.). Dimension Two is the cross-cutting concepts that are a part of the NGSS framework. While in the Minnesota Department of Education's (MDE) curriculum map, these cross cutting competencies have no direct application application to strand, substrand or standard they are key concepts that tie learning on an interdisciplinary level within the science standards to reinforce scientific world view for the learner, they are:

- Patterns
- Cause and effect: Mechanism and explanation
- Scale, proportion and quantity
- Systems and system models
- Energy and matter: flows, cycles and conservation
- Structure and function
- Stability and change

These concepts are intertwined within the strands, substrand and standards as glue, meant to interweave bigger concepts in the map (education.mn.gov, n.d.). The Third Dimension: Disciplinary Core Ideas serve as content area markers in the map, they are:

- Physical Sciences

- Life Sciences
- Earth and Space Sciences
- Engineering, Technology, and the Applications of Science

Within these four content areas, there are thirteen subcategories to specify and categorize each core idea (education.mn.gov, n.d.). There are four strands and eight substrands in the MDE curriculum map:

- Exploring phenomenon or engineering problems
    - Asking questions and defining problems
    - Planning and carrying out investigations
- Looking at data and empirical evidence to understand phenomenon or solve problems
    - Analyzing and interpreting data
    - Using mathematics and computational thinking
- Developing possible explanations of phenomena or designing solutions to engineering problems
    - Developing and using models
    - Constructing explanations and designing solutions
- Communicating reasons, arguments and ideas to others
    - Arguing from evidence
    - Obtaining, evaluating and communicating information

From these strands, substrands, and key concepts the map assembles the benchmark for the entire standard (education.mn.gov, n.d.). This project showed *the benefits of advancing the Next Generation Science Standards in the elementary grades* by using the existing framework from the MDE, reorganized to accommodate for a gap in the curriculum at the fifth grade level. While these standards were accommodated within the kindergarten through fourth grade curriculum, they were moved without losing the intent of the original authors, only seeking to enrich the original key concepts and reinforcing science-minded curriculum as elementary students progress into a secondary school setting.

Once the map was rearranged, I included into the new template some ideas for the use of this gap in the curriculum. The curricular shift, even only if in theory, potentially left room for a year of inquiry for enrichment, remediation for those who have struggled to embrace the core concepts, test prep, cross-curricular job field investigation, and core concept-related independent study. All of which, in concert with the NGSS-based framework, could foster scientific thinking in the elementary student as they move into a secondary school setting.

Conclusion

This chapter has shown what the current science curriculum maps are attempting to accomplish by implementing NGSS standards in their curriculum. It has given insight into the benefits of a careful, structured and deliberate restructuring of the existing NGSS-aligned science curriculum for the State of Minnesota by advancing NGSS standards in the elementary grade as a supplement to the thought put into its original authors as a vehicle for academic change. In Chapter Four I will clarify the question: *What are the benefits of advancing the NGSS standards in the elementary grades?*

Chapter Four

Conclusion

Introduction and Overview

What are *the benefits of advancing the Next Generation Science Standards (NGSS) in the elementary grades?* They are as vague or precise as one would wish them to be. The benefits could be as wildly different and far-fetched as asking yourself: *What would you do if you had all the time in the world?*. The framers of the Next Generation Science standards have crafted their curriculum map using the recurring themes of science and engineering practices, cross-cutting concepts and disciplinary core ideas (National Resource Council, 2015). This curricular change focused on a curricular approach rather than a change in content. This is also where the research in the literature review led me. I found that when I looked at how other nations organized their standards, countries who habitually outperform the United States in academic success, the how and the why began to take a front seat to the importance of when standards were taught. These countries are outperforming the United States without the use of buzz-words employed within the Next Generation of Science Standards. Upon further reflection, cynicism to the efficacy of this new approach and the need to think critically about the need for something supplemental to bolster these new standards, became a catalyst for the development of a project involving a change in the curricular map. Plying our students with cross-cutting concepts is not going to be enough impetus to forge lifelong scientific learning. Student competencies and familiarity with the foundational ideas and concepts of the Next Generation Science Standards is a starting point, but in order to truly rope them in, to activate and engage them to a point where they at the very least consider science to be a part of their curricular choices going forward or even a science or engineering career later in life, is going to take additional efforts within the walls of the schoolhouse.

In the literature review I researched hurdles standing in the way of the curricular implementation and changes required to meet those hurdles. The review looked into curricular development and its ties to the past policies involving curriculum and curriculum policy in the United states. The most telling part of the review was the dive into how other nations implemented science curriculum as this gives an avenue to those seeking a genuine comparison in curricular models and how a potential radical shift in our own curriculum might be facilitated. From nation to nation, province to province, curriculum was similar but at the same time, very different. In Canada, one province would introduce a standard earlier than another, while at a later grade with another. Yet from the west to the east, by the time their students reached middle school, all of the similar foundational standards were presented. Canada, as I noted in the literature review, has no formal, national department or ministry of education. They leave policy and planning to the provinces and offer only financial support. Hurdles were also reviewed in the second chapter and again our Department of Education and its past policies end up being another focal point of why we're rolling out a new science curriculum in the first place, deciding who inevitably will be involved in the building and implementation along with its past policies. The Next Generation of Science Standards (NGSS) were Developed by the National Resource Council, A think tank that formed in 1916 at the request of President Woodrow Wilson to have an organization of scientific specialists to solve scientific problems (Rexmond, 1978). It receives no direct departmental funding on the national level, in favor of grants from the Departments of

Transportation, Defense, Education, Energy, Veterans Affairs, Commerce and NASA as well as a fifth of its income from the private sector (nationalacadamies.org, 2021). This is notable from the standpoint of Past Policies as addressed in the second chapter. Whether it was the National Defense Education Act (NDEA), giving money to groups and individuals for education so long as it could be attributed to national defense during the cold war 50s and 60s, to the Regan-era *A Nation at Risk.* A publication espousing non-existent deficiencies in the educational system of the time, attempting to assign blame while recommending implementations that eventually were not used (USA Today Magazine, 2003, p.1). To the recent *Project Lead the Way,* or as we know it in our schools: Science, Technology, Engineering and Mathematics or STEM education. It's projects, initiatives, training sessions are almost solely funded from Fortune 500 companies and private philanthropic foundations and their desire to have a hand in school to factory pipeline (pltw.org, 2021). All of these remedies, past and present whether they originate from the public and private sector, have no shortage of ideas on how to improve the educational system. The NGSS, for its part, seeks to create learners with a strong science foundation (National Resource Council, 2015). With these past efforts in mind during the review of the literature, it became easier to consider an unamended science curriculum while avoiding the questionable efficacy of past curricular policies.

Major Learnings

My single biggest takeaway from this research in searching for an answer to my question was the comparisons of how other nations implement their science curriculum. It's apparent that there is so much standing between my question, the project bringing this question to life and the potential implementation of my adapted curriculum. Teacher belief and content knowledge, internal and external bureaucratic hurdles and past policies are all issues that were addressed in the literature review and seem to be ever-present in any curriculum implementation, regardless of subject matter or grade level. Other nations, like Canada, who seem to benefit from a lack of centralized leadership in their curricular policy making decisions, or Japan, for their part don't introduce formal science curriculum to their elementary schools until the third grade. In both instances, these nations score higher than the United States in global education rankings (worldpopulationreview.com, n.d.). It was in this seemingly intangible discovery that I began to formulate the thought that there was room to move curriculum and not discard standards, all while creating an environment that held true to the initial desires of the NGSS of student-centered, highly participatory science curriculum to engage the students. The aforementioned bureaucratic hurdles need to be addressed before there can be any true and effective change with any curricular policy. In the state of Minnesota, as I mentioned in the second chapter, curriculum is reviewed on a ten-year cycle and the NGSS-aligned science standards coincided with the state's curricular review. Minnesota's legislature and Department of Education has made the decision to forgo direct NGSS implementation in favor of a curriculum that is NGSS-aligned, due to the lack of direct multicultural/indigenous considerations within the NGSS standards (education.mn.gov, 2019).

Implications and Limitations

Red tape, bureaucracies, and apparent lack of multicultural/indegenous sensitivities notwithstanding, how would *the benefits of advancing the Next Generation of Science Standards (NGSS) in the elementary grades* move the needle on student engagement?

Before that question can be answered, I have to address the implications of the last section, particularly as it relates to educational bureaucracy. In order to implement this curriculum in a state like Minnesota, it would have to pass, unchanged and unamended, through the state legislature and meet with the approval of the State Department of Education. While the legislature and Department of Education live in a kind of harmonic symbiosis, the Department's chair. Imagine for a moment, that this curricular change has the full faith and credit of the state house and this amended curriculum is ready to be rolled out, giving a year of inquiry, independent learning and enrichment to fifth graders statewide. We now have to address the true limitations of my research question and project: The teachers. As I addressed in the second chapter, a major hurdle with any curriculum rollout is teacher belief and content knowledge. The NGSS for its part, in its design was meant to quell those fears. The NGSS touts itself as a curriculum that will benefit from doing away with rote worksheets and memorization, pre planned outcomes and the need for extensive scaffolding for struggling learners (National Research Council, 2015). Replaced instead with student led investigations, developing vocabulary as-needed, discussions of open-ended questions and system thinking and modeling. By advancing the NGSS standards in the elementary grades, all the standards will have been taught by the fourth grade. Fifth grade teachers would be free to take what their students have learned and allow their students to engage in the sciences of their choosing. A year of inquiry or independent study would reinforce all of the tenants that the NGSS is trying to instill in the elementary school-aged learner. It would allow and encourage them to retain the natural curiosities that children of this age already have. In many ways, a shift in the curriculum of this nature would encourage them to never let it go. The only thing standing in their way are the adults.

Going Forward

This project is theoretical. A constructed curriculum map, altered to create an idea. An opportunity for an edenic learning experience within the science curriculum of an elementary school. I have every intention of sharing this work with the Science Curriculum Committee in my own school district, if only to serve as a template for what is possible. I also hope that it finds the eyes of an educator that is in search of something outside the box. The undisturbed, state-approved curriculum has been mandated for implementation in Minnesota by 2024 and I feel there will be a lot more data on the potential success of this curriculum over the next five to ten years. Regardless of whether it's implemented as written or NGSS-aligned in its design. The future will tell us whether the framers of this curriculum have created a better path for our children or if they have succeeded in repeating the same folly of the past. I would like to think that my project stands sentinel, reminding anyone who reviews it, that there is always another way. An alternate way. Perhaps it's the road less traveled. Perhaps it's as naive as the curricular policies of the past. In developing this project and researching this question, I found myself being constantly reminded of the experiences in science that I had when growing up. This project would be the best reflection of those experiences that I could share.

Conclusions

For as long as it's been a part of the core curriculum, educators and administrators alike have tried to find a way to get kids to engage and stay involved in science curriculum. The NGSS contends that it has found the way. While they may be close in many respects to initiating a student-centered curriculum in science investigations, in the end, without an event, a moment in time for students to exercise what they've learned, their set of standards and concepts, as written, will fall short in their objectives. The key tenets of science and engineering practices, cross-cutting concepts and disciplinary core ideas won't be enough to engage and hold the imagination of the scientific mind as the student moves from the elementary and into the upper grades. My project, however, will create that moment, that event for students to shine. Like any curricular plan, it has its detractors. It may take the bravery of a state legislature and department of education. It may have to portage its way around educators with the twenty year pin who resist change in any form. It may have to win the hearts and minds of teachers who've never liked science and never felt comfortable teaching it. It may have to survive the onslaught of helicopter parents who will want to know why there isn't any formal science curriculum for their fifth grader. It will have to be given a chance to grow in the fertile soil of science.

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