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# Three-Dimensional Learning and the Phenomena Based Learning Approach with a STEM Curriculum

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# THREE-DIMENSIONAL LEARNING AND THE PHENOMENA BASED LEARNING APPROACH WITH A STEM CURRICULUM

by

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# CHAPTER ONE

## Introduction

STEM schools and the integration of STEM curricula into regular curriculum has been on the rise for quite some time across the country. A person would be hard pressed to find someone that is not familiar with the increased popularity in STEM education. STEM stands for the core subjects of Science, Technology, Engineering, and Mathematics with a goal of helping students succeed in the rapidly evolving technological society. According to Gerlach (2012), STEM education is an interdisciplinary approach to learning that uses real-world lessons for students to make connections between school, community, and work. While the concept of using real-world problems is not new to education, it is an approach that I feel most passionately about. Students make stronger connections with the information they are learning if they can connect it with what they are seeing, living, reading, and watching.

As the world becomes more technology-driven and jobs are adjusted with new technology, it is important that students adapt to these changes in their educational career to be better equipped to jump into the workforce. According to Fioriello (2019), “the National Science Foundation estimates that 80% of the jobs available during the next decade will require math and science skills” (p. 2, para. 9). As that is a large percentage, students must stay proficient in these areas of study. If proficient, they will be able to be successful in the ever-evolving job market of the 21st century. As not only a brand-new teacher, but a STEM Specialist for first through fifth grade, I have many questions on what types of approaches best suit the STEM classroom. As someone who struggled in science and mathematics in school, I want to make sure that I can effectively reach all students so that they have the best opportunity when entering future classrooms and the workforce. This leads to my research question: *How do three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?*

**Three Dimensional Learning and Phenomenon-Based Learning**

The new approaches being implemented within the new science standards are three dimensional learning and phenomenon-based learning. The new science standards are to begin in schools within the next few years. There are plans of a slow roll out among grade levels as to not bombard teachers with significant changes. These changes will affect the plans of daily teaching for all educators. Our district has been taking a proactive approach to implementing these new standards and learning approaches within our schools by having routine meetings with the Science Leadership Team. This team is made up of educators, learning specialists, district officials, and the STEM specialists from the school district. These meetings allow for the district leadership team to learn about these new science standards and approaches. During these meetings, we have addressed the issues that are currently taking place in our classrooms. The goal of these meetings is to become proficient in the information, so that we can bring this information back to each one of our schools.

Three dimensional learning, also known as 3D learning, is an approach that engages students with the use of scientific and engineering practice while applying

Crosscutting Concepts as tools to help develop the understanding of and solving of problems (*What's so Phenomenal*, 2019). The 3-D learning approach is to be intertwined with the phenomenon-based learning approach. Both of these concepts work interdependent on each other in order to successfully incorporate science education on a daily basis within the classroom.

A scientific phenomenon can be defined as some sort of observable event that occurs in the universe. "Phenomenon-based learning is a holistic, interdisciplinary approach in which the starting point for inquiry is that specific, observable, real world event" (*What's so Phenomenal*, 2019, p. 6). The universal phenomena can be used in the classroom, phenomenon-based learning, to help instigate a student's curiosity and require the use of scientific reasoning as well as engineering practices while discussing and exploring a topic. A more in depth explanation of phenomenon-based learning will be discussed later in Chapter Two.

**Personal Background**

I had an educational career path that mirrors many students in suburban America. I went to a public school in Texas and stayed within the same school district for all twelve years of schooling. My elementary school was consistent and proactive in keeping up with the evolving educational approaches. I felt that our school was, at times, a few steps ahead of other schools. I recall all my academic subjects, and they were split up into different times throughout the day. The subjects I struggled in most were science and mathematics. There were certain aspects to science that I struggled with, but I always maintained a slight interest. I feel now that if there had been a better learning approach applied during that time, I would have been more successful. My thoughts also apply to mathematics, but I would need to save that for a whole other research topic. I find that the educational system I was raised in was in-line with the classical learning approaches. We read a lot from textbooks, and we worked from our textbooks. It was a lot of memorization, lecture-based learning, and making quick connections based on information we read or worksheets we completed. Being that I am a bit of a hands-on learner, I felt that if I had been given the opportunity to use a phenomenon-based learning approach, then I would have made more consistent connections.

The other piece I can recollect from my own personal learning is the big emphasis my school put on "saving our planet." The school was environmentally proactive, and we definitely talked often about how to keep the Earth "healthy." I remember learning about this and feeling so passionate about it. That passion stayed with me into my adult life. I feel like I am a big advocate on energy conservation and taking the necessary steps to take care of the Earth. I remember doing our own research on the subject and working in teams to come up with ways our school could make an impact on taking care of our earth. This was impactful. We even did a performance in third grade called, "Reduce, Reuse, Recycle." I can still remember some of the choreography! I was front and center for the main song that closed up the performance that honed in on the idea that we can make a change if we reduce, reuse, and recycle. Throughout all grade levels, we reflected on the importance of taking care of our planet. This got me thinking that energy conservation, in an elementary setting, is the perfect time to begin discussing the different ways we can take care of our planet. If we begin teaching the importance of having a healthy earth, then students will be more likely to carry that concept into their adult years. The emphasis on energy conservation beginning as early as elementary school will hopefully allow for a society of more earth-conscientious citizens.

**Becoming a Teacher**

As a person that always enjoyed being the “mother hen,” it only seemed natural that working in education would be enticing for me. I always was the person in class that lent a hand during projects or areas of study that I was stronger at. I enjoyed the satisfaction of helping someone understand the task at hand. My first teaching experience was teaching dance. I taught dance for numerous years and loved working with all ages. I wanted to be the teacher that students felt comfortable with and learning from. I strived for dancers to not only learn the material but to learn to be kind and thoughtful.

My undergraduate degree was a Bachelor of Arts in Dance and a minor in Health Education. I felt this would give me an opportunity to aid students in making good decisions for their health and provide them with knowledge that, again, they could carry over into the real world. When moving to Minnesota, I realized that I would need additional credits in order to obtain a teaching license. That meant that I had to return to school. Luckily, I was able to pursue my Masters and obtain my Minnesota K-6 Teaching Licensure. It was during this time that I found a passion for science and social studies. These were subjects that I had interests in but not to the extent that I have now. My professor for Teaching Elementary Science was passionate and taught engaging teaching approaches for science. That course made me feel excited to teach science and I look forward to providing the same experience for my future students. While I was in my licensure program, I was excited and nervous to start teaching.

**Current Teaching Position**

My current teaching position, as I mentioned previously, is a STEM Specialist at an elementary school in a suburban school district outside of the Twin Cities. There were very few opportunities being posted in the school districts that I was applying to. I was fortunate that an opportunity came my way. I had my fingers crossed for a grade-level position so that I could build relationships with the students for the year and send them on their way to become successful individuals. Those plans changed a bit when I was offered a STEM specialist position. I would still be creating relationships but with this role, I would not be working closely with a small group for 25-30 students but with the entire building. Even though the position itself was intimidating, I felt excited at the idea of being a STEM Specialist. I felt I had the inspiration and drive to create a curriculum that would engage students' curiosity.

The idea of the STEM position also reverted me back to the feelings I experienced during my course of Teaching Science in Elementary School. The other benefit to the position was that I had the flexibility to adjust the curriculum lessons as long as they fit the standards that were required of the STEM teacher. This brought on excitement for me because I felt there were unlimited possibilities. Along with the excitement, it brought on fear as well. I knew this was a big responsibility, and I needed to do my due diligence so that I could be an effective STEM teacher for my students. I began reviewing the school's STEM curriculum and the lessons that have been taught in previous years. I mapped it out and started attempting to brainstorm what I could adapt or adjust. This is when I began to be overwhelmed. I realized that I would need to take it step by step. Once I had an overview of the units of study, I could slowly work my way through the curriculum as needed so that I could be best prepared for the lesson when it was time to teach. During this time is when I questioned what the most effective STEM teaching approaches were. I want to make sure I use the most effective approaches so that my students can have the most authentic learning experiences during their class with me. The importance of using the most effective approaches is so that I know the students are making solid connections and will gain the skills necessary to be successful in their future. STEM exposure is necessary so that there can be increased critical reasoning and logical thinking developed (Marrero et al., 2014). These skills would be beneficial and would come from effective learning approaches in order to become proficient in STEM related subjects. The importance of this proficiency is that the students are better equipped to take on a degree plan that fits the rapidly growing career sectors that are in STEM related fields.

**Learning Approaches Currently Used**

The current learning approaches used in teaching STEM and/or the subjects involved are problem-based and/or project-based. While problem-based and project-based learning approaches have been relatively effective in the classroom and have been used for numerous years, it has been questioned if they are the "most" effective way to teach these certain subjects. Bloom (2016) found that there has been major research proving that project-based learning approaches leave disadvantaged students behind (p. 1). Problem-based learning is where students are solving an open ended problem about a certain subject or topic. Project-based learning is when students gain understanding through the use of real world issues and problems when learning about a specific topic. Both problem-based and project-based learning are "student-centered" learning approaches. Learning approaches aside, there is also an issue with the amount of instruction time students are receiving with science education in elementary schools across the nation.

There has been a lack of science education in elementary settings across the nation, and these upcoming learning approaches are to help create the ability to get science back in our classrooms. As of now, in traditional schools students may only rotate through science in three week increments. If students are lucky then there may be some sort of STEM related class that they may rotate through on occasion. It is my opinion that there is a void in the students' education with this limited exposure to science. The National Science Teachers Association supports this idea of providing more effort in routine science instruction when they state that schools should be striving for at least sixty minutes a day (NSTA, "NSTA Position Statement," 2018). As of now, the majority of elementary students nationwide are not receiving this amount of science education.

**Looking Ahead**

In this chapter, I introduced the concept and importance of STEM education due to the rapidly growing career sectors involving STEM related subjects. I also discussed my own personal educational background, my pathway to becoming a teacher, my current educator position, and the upcoming learning approaches being implemented into the new science standards. This background information brings to life the importance of my research to answer the question: *How do the three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?*

In Chapter Two, I will take a closer look at STEM education and the different ways STEM is implemented in schools as well as three-dimensional learning and the phenomenon-based learning approach. I will also dive deep into the benefits of STEM education for our students and the importance of early exposure. Finally, I will be creating a resource that will provide educators with an example of a quality STEM unit that exhibits the three-dimensional and phenomenon-based learning approach.

# CHAPTER TWO

## Literature Review

### Introduction

To gain insight on the importance of STEM (science, technology, engineering, and mathematics) in elementary education, it is important to first review what STEM is and how it is implemented in the various school systems. This will give a better view of the different types of STEM education that students are receiving around the state of Minnesota. Second, it is imperative that the new learning approaches, three-dimensional learning and phenomenon-based learning be discussed in order to fully understand how these new learning approaches proposed by the Next Generation Science Standards will provide for a more authentic learning experience. Third, there will be information provided on the benefits of STEM education in an elementary setting. There could be some hesitations or concerns to incorporate STEM into daily lessons by educators if they do not feel confident or proficient in the STEM disciplines. In order to effectively teach STEM, it is important that educators are provided with resources and support to aid them in implementing these new standards. Therefore, the need for proper teacher and curriculum support will also be discussed as educators will be more successful if given proper resources and guidance. Finally, the impact of STEM education on students' future classes and the impact on students' lives outside of the classroom, such as in the workforce, will be addressed. This basis of understanding will allow for an answer to the question: *How do the three-dimensional learning and phenomenon-based learning* *approaches increase the authentic learning experience for students in elementary STEM classes?*

**What is STEM?**

The rise in popularity for STEM is evident with the upcoming changes to the national science standards that implement STEM, yet there are still quite a few people who do not fully understand what STEM education embodies. While the increased hype of STEM started around the early 2000s, STEM was actually developed around the 1990s. Bybee (2010) stated, “STEM had its origins in the 1990s at the National Science Foundation (NSF) and has been used as a generic label for an event, policy, program, or practice that involves one or several STEM disciplines” (p. 30). With that being said, some still ask, “What is STEM?”

STEM can translate to different ideas and look different to many people or schools. In fact, there are quite a few areas around the U.S. that either do not incorporate STEM or barely implement the concepts of STEM in their curriculum. Mathematics, being a discipline of STEM, is being taught daily, but science is getting far less exposure. The disciplines of engineering and technology that are getting less exposure as well. The use of the four disciplines that make up STEM in our education is important. According to Marrero, Gunning, and Germain-Williams (2014), “The term STEM, an acronym for science, technology, engineering and mathematics, has come to the forefront of international discourse in education, industry, innovation, and competition” (p. 1). While there is not a lot of information on the actual percentages of schools in the U.S. with

STEM education, there is a lot of change and movement influencing schools to incorporate STEM in their curriculum.

As mentioned previously, STEM has been present for many years. One of the reasons STEM grew in popularity was due to the concerns of politicians and other leaders that U.S. students were not keeping pace with other students around the world and would not be prepared for the fastest-growing career sectors. Data released in 2015 by The Programme for International Student Assessment (PISA) placed the U.S. as 38th out of 71 countries in math and 24th in science (as cited in McPhillips, 2016). Data prior to this showed the U.S. behind many other countries in regards to science and math, which amplified the concern and need for STEM in education. The *New York Times* recently published an article of the current PISA test results for 2019 that were received from 79 educational systems around the world; results show the U.S. underperforming in reading, math, and science (Goldstein, 2019).

The concern also developed from the high demand of professionals in career sectors that fall under the STEM umbrella. Economies in science, technology, and innovation have dramatically grown, which caused an increase in demand for professionals in these fields. In 2009, the Obama administration announced its plan to support and push the implementation of quality STEM education in schools (Educate to Innovate, 2013). Thus, began the initiative known as "Educate to Innovate," which had numerous goals that would help encourage and prepare students to be successful in STEM. The main goal was to help move American students from the middle to the top of the pack in science and math achievement  (Educate to Innovate, 2013). This effort by the

Obama administration has proved successful since the language of STEM is now seen integrated with the science standards and has become an important topic in education. STEM education allows for students to participate in engineering design and/or research in order to experience meaningful learning through integration and application of mathematics, technology and/or science (Thibaut et al., 2017).

Administrators and teachers are now more aware of what STEM is and how to utilize it in schools. In 2011, there were at least 40 schools with STEM education or transitioning into STEM magnet schools, and even at this time it was said to be spreading nationwide (Smith, para 1). Therefore, STEM schools or STEM magnet schools are beginning to become mainstream.

**STEM in Schools**

STEM education in schools looks different throughout the various school districts. There are schools that heavily integrate STEM within their curriculum and then there are some schools where STEM is a “specialist” class that students attend once a week similar to the rotation of music, physical education, or art. Due to the lack of training and qualified teachers for STEM education it has allowed for STEM to be disjointed (Chen, 2012). Therefore, schools that often departmentalize the subjects will look to a “specialist” to teach a STEM class. While STEM looks differently in schools, as I previously mentioned students are receiving their traditional math class daily but possibly do not receive regular exposure with science education. What regular exposure to science looks like in schools also varies greatly. Science can be a three-week course that students rotate through or it can be a subject that is taught twice a week. It is all dependent on the school district on what science education will look like in their schools.

The amount of STEM education presented in the school can also fall onto the funding. Creating a STEM program within a school requires funding like any other new program (Chen, 2012). This means that schools in certain areas may lack the funding or resources to create a proper STEM program. There are some schools that are able to take a more active approach to implementing STEM within their schools, and they are known as STEM schools or are charter schools that have a STEM driven focus. These schools are registered as STEM schools and receive their funding based on their STEM-focused mission. Funding may be provided through various sources and schools or charter schools have the ability to receive grant options. For instance, The National Science Foundation has provided two different grants to help advance STEM education by providing funding to create new types of science labs in school (Chen, 2012). That is just one of the many options for grant funding that can be available to schools.

STEM focused schools are becoming well known and some public schools have even adjusted their mission to reflect a focus on a heavily integrated STEM curriculum. Schools such as those will usually adopt a program that helps make that transition. On the other hand, some schools incorporate STEM at a lesser level. Again, this can be due to lack of funding or resources. In those types of schools, STEM is seen as a specialist class and the students see these teachers on a routine basis but less frequently than students would in a heavily integrated STEM school that puts it at the forefront of their school's mission.

Project Lead the Way is a program that partners with public schools and charter schools in the U.S. to help create STEM-focused schools by giving those schools the resources to execute an appropriate STEM curriculum. According to Project Lead the Way (PLTW), there are 12,200 schools that they have partnered with in the U.S with about 150+ schools being in Minnesota (PLTW, 2019). The amount of schools listed with Project Lead the Way gives reasonable insight as to how many STEM schools are present considering this is just one program helping produce STEM in schools. There are other companies that offer programs similar to PLTW or curriculums available for schools to take advantage of. This means the number provided by PLTW is only a small portion of STEM-focused schools in the U.S.

If schools are not partnering with a company to help create a STEM-focused school there are other resources available to educators to help advocate for appropriate STEM concepts. One resource that can be accessed by Minnesota educators is the website, scimathmn.org. SciMathMN is “a five year old grassroots initiative to form a community of practice among STEM stakeholders in the state to work toward common goals of STEM awareness, quality teaching and learning, and increased interest in the STEM workforce” (SciMathMN, 2019, About, para. 2). SciMathMn is a great resource for Minnesota educators as the website connects educators with the current frameworks for science and math and provides information that can be used to help create effective curriculums. A non-profit business, SciMathMN was created in partnership with education in promoting quality science, technology, engineering, and mathematics in Minnesota K-12 schools (SciMathMN, 2019). They are also partnered with the

Minnesota Department of Education to help develop the frameworks currently used in the classrooms.

As mentioned previously, there are charter schools that put an emphasis on STEM being integrated into their curriculum and charter schools that are primarily STEM-focused schools. STEM has become increasingly popular and public schools are even changing to be considered “STEM” schools. In Minnesota alone, there are around 40+ STEM programs in Minnesota within the public school system (PLTW, 2019). These numbers keep increasing as STEM becomes more integrated into the common core standards. According to Smith (2011), “The STEM initiatives are spreading nationwide, spurred by an increased emphasis on science and math and pressure to fill a job market void with future engineers and science-savvy students” (para. 5).

Students need STEM education so that they are better prepared to pursue fields that require this knowledge. Experts believe that STEM understanding and exposure for students will ultimately be beneficial to many people around the world, including, but not limited to, students who will end up seeking professions in STEM-related careers (Marrero, Gunning, & Williams, 2014, p. 1). Early exposure in elementary schools and integrating STEM in middle and high school will only help meet the needs of workers in STEM related fields. In order to incorporate STEM properly in a school setting there needs to be proper support for educators. Therefore, teacher and curriculum support is essential to the success of a school’s STEM program.

**Teacher and Curriculum Support**

The success of STEM within a school truly derives from the support within the school district. The support received for teachers is totally dependent on the school district and the approaches taken within that school district towards implementing STEM. The more proactive a school district is towards providing support to the teachers the more successful STEM can be. Teacher attitudes towards STEM are greatly impacted by the support or lack of support received as well as other factors. According to Thibaut, Knipprath, Dehaene, and Depaepe (2017):

> Within the field of STEM education, the National Research Council (NRC) report (2011) has identified elements that are shared by schools that showed improvements in student learning in STEM. In this report, school leadership was named as the driver for change (p. 195).

Therefore, a property of successful teaching in STEM comes from adequate support for teachers. Some reasons for improper implementation of STEM education can be due to teacher attitudes or anxieties towards the integrated subjects. There is an abundant amount of research that shows a relationship between feelings of anxiety and classroom practices. These anxieties can create negative attitudes towards teaching STEM education and these anxieties are a result of inadequate professional development. Within a research study conducted by Thibaut et al. (2017) on the relations of teachers' attitudes and practices, "findings indicate that teachers' attitudes can act as a lever for improved STEM education" (p. 202). The research supports the idea of proper support from the principal and school administration.

Contributing factors that are crucial in improved education would be support, guidance, and leadership by administration for the success in implementing proper curriculums in general but also with regards to STEM (Thibaut et al., 2017). The type of professional development for STEM with educators is dependent on how STEM is implemented in the school district. If STEM is not heavily influenced by the curriculum then the support may be lacking. If it is a STEM school, then there may be more support for the teachers.

There are many types of programs for schools to work with, for example, Project Lead The Way (PLTW), a company that a school can partner with to gain STEM curriculum and resources (PLTW, 2019). Upon researching there are many options of curriculums to be used. Some of these different curriculums are created by universities, non-profits, or educators that have all been created with the K-12 Framework and to align with the Next Generation Science Standards. A few programs that are widely used with teaching STEM education are *Amplify Science* and *Engineering in Education* (EIE). Amplify Science is a company similar to Project Lead The Way. Currently, Amplify partners with 21,000+ schools in the nation. The company, Amplify, provides more than just STEM curriculum but also core curriculum supplements and assessments (Amplify, 2019). Their goal for their program is to provide teachers with the tools that help them understand and respond to the varying needs of students. Amplify is a program that has already taken on the new learning approaches that the new science standards propose. Amplify Science strives to create a “next-generation” curriculum and assessment with captivating core and supplemental programs in ELA, math, and science. The adaption of the new learning approaches along with the created curriculum Amplify offers engaging and rigorous learning to inspire students to think deeply, creatively, and for themselves (*What's so Phenomenal*, 2019, p. 13).

These types of programs offer great support to schools so that they can effectively implement STEM into their system through their curriculum and supplemental resources. Another option for schools is to purchase a package that provides resources and a curriculum to implement in their classrooms. All partnering programs have similar missions and that is to create a quality curriculum that integrates many subjects within STEM education. The upcoming changes to the standards with the Next Generation Science Standards will be required in all schools no matter the science or STEM curriculum that is chosen by the school district. Therefore, it is important that schools are providing quality resources and support so that teachers can effectively incorporate STEM within their classroom since that is what is expected of them with the upcoming, new science standards.

**Next Generation Science Standards**

The Next Generation Science Standards (NGSS) are the standards in which school districts build their science and STEM curriculums. Due to STEM language becoming more present within the Next Generation Science Standards, STEM has become influential on educational systems to include in their curriculum. The Next Generation Science Standards were developed by educators, content experts and policymakers, using a guiding document called the Framework for K-12 Science Education from the National Research Council. The K-12 science standards were developed by and for educators and therefore districts, schools, and non-profit education entities may copy, alter, edit, and rearrange any parts of the NGSS without needing permission (NGSS, 2019).

The wording within the NGSS website states that it gives schools permission to use the K-12 Framework however they see fit. Due to this freedom, schools or districts may allow for the option to adopt a science curriculum or partner with a program that offers a quality STEM curriculum with resources as long as it aligns with the K-12 framework. The Next Generation Science Standards go through multiple drafts and multiple hands before being released for implementation. According to NGSS, there are two steps taken to draft the standards. The first step deals with the development of the Framework for K-12 Science Education by the National Academy of Science, an extension of the National Research Council (NRC). The framework set forth by the National Academy of Science is crucial as it incorporates the most current research and science that is expected to be known upon completion of high school. The framework is completed through a committee organized by the NRC and this committee is composed of many influential individuals in science and education. The framework has four design teams that are broken down into physical science, life science, earth/space science, and engineering. Each team develops the framework for their prospective area of disciplinary.

Step two incorporates the states in helping to develop the "Next Generation Science Standards" to ensure that the content is enriching and thorough with an organized vertical alignment to help provide students with adequate education to fulfill the necessary requirements at completion of high school (NGGS, 2019). The NGSS goes through numerous reviews:

> The NGSS were developed collaboratively with states and other stakeholders in science, science education, higher education, and industry. Additional review and guidance were provided by advisory committees composed of nationally-recognized leaders in science and science education as well as business industry. (NGSS, 2019)

The review process is lengthy and there are many rounds of reviews before standards are approved. The end result is a final draft of standards that prepare students to be college and career ready. In the upcoming subtopic, phenomenon-based learning is discussed in greater detail. The NGSS includes two types of phenomena within the standards and they are anchoring and investigative. Those two types of phenomena used are how the guiding questions are approached within a lesson. The investigative phenomena is a sub-component to a related anchoring phenomenon (The Lawrence Hall of Science, 2019, p. 7). The Next Generation Science Standards are being improved based on the incorporation of three-dimensional learning and the phenomenon-based learning approach.

**Phenomenon-Based Learning**

"A scientific phenomenon is an observable event that occurs in the universe—one that we can use our science knowledge to explain or predict" (The Lawrence Hall of Science, 2019, p. 6). As mentioned previously, phenomenon-based learning is an approach in which the learning begins with the inquiry of a real-world scientific phenomena. The phenomenon-based learning approach is focused around the concept of doing to understand versus doing to do. Therefore, doing is investigating to find the "answer" to the guiding question that revolves around a scientific phenomena/real-world event (See Appendix A). Phenomenon-based learning is an approach that is taught with a multidisciplinary curriculum.

While phenomenon-based learning is new to the US, Finland and Scandinavia have been using this approach for decades to improve their pedagogical approach. In Finland, they use multidisciplinary learning modules (MLs) that are taught in school with the phenomenon-based learning approach. The pedagogical goal with the MLs is so that more than one subject can be taught within one unit in an effort to create transversal competencies (Symeonidis & Schwarz, 2016, p. 35). According to Symeonidis and Schwarz (2016), "MLs aim to engage students in exploring holistically authentic phenomena, which are interpreted as real-world themes and as such cannot be contained in only one subject" (p. 35). In other words, Symeonidis and Schwarz are stating that more than one subject can be taught simultaneously making it a more efficient learning approach. According to Symeonidis and Schwarz (2016) the following was written about pedological reform in Finland:

> Throughout the curriculum, and particularly in subject-related sections, the term phenomena is often employed to indicate things as they appear in our surroundings or experiences that are observable and can be explored. The specific term seems to penetrate the content of the new curriculum, making clear a pedagogical direction toward learning through and about real-world topics that

> have practical impact for students and help them develop competencies essential to their lives. (p. 36)

Implementing phenomenon-based learning within a curriculum helps to interweave the core subjects in order to develop transversal competencies within different fields of knowledge and skills (Symeonidis & Schwarz, 2016).

Many educators believe previous approaches, such as the inquiry-based approach, sought to build understanding yet did not always create authentic learning. The inquiry process is still embedded in the phenomenon-based learning approach but the methods by which students are “asking” questions are less lecture-based or methodical and are more exploratory.

The U.S. state science standards are currently in the drafting phase to introduce and integrate the phenomenon-based approach along with three dimensions of learning. The new vision for the updated science standards features a three-dimensional view of learning that involves: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas (NGSS, 2019). The phenomenon-based learning approach is asking “why” a phenomenon happens and having the students act like scientists and thinking like engineers instead of learning by lecture. The phenomenon-based learning approach offers a leading question that the educator can help guide the students along to answer the guiding question or questions by students thinking like a scientist and an engineer to solve real-world problems.

Multimodal learning is touching on all the different ways students learn such as visual, auditory, reading/writing, and kinesthetic. It is stated by NRC (2019) that starting with phenomenon-based learning will allow for three-dimensional learning to follow (Amplify, 2019). The possible evidence sources are derived from first-hand sources and second-hand sources. First-hand sources used are documents, images, or artifacts that are considered "evidence." Second-hand sources would be sources used that are not a first-hand account or experience of a certain event or discussion. The multimodal learning method within the phenomenon-based learning approach is to quantify, read, talk, write, critique, argue, and think like a scientist (The Lawrence Hall of Science, 2019, p. 8). Through collaboration, engagement, observations, investigations, background knowledge, making references, and cycles of questions, the original guiding question of phenomena can be discovered by the students themselves. The phenomenon-based learning approach begins with introducing a phenomenon and a related problem, the students collect the evidence from multiple sources (first hand and second hand), build increasingly complex explanations, and apply knowledge to solve a different problem (Amplify, 2019). The goal is to engage multiple times and multiple ways to create multiple chances to learn. The multimodal way of learning that takes place during this approach means it would benefit all the various types of learners.

Digging deeper into phenomenon-based learning there are two types of phenomena: anchoring and investigative. They are interdependent in this learning approach in the fact that the one phenomena "anchors" and the investigative phenomena is a sub-component to the anchoring phenomena (The Lawrence Hall of Science, 2019, p. 7). Amplify Science stated, "If we want students to engage in learning about the natural world as scientists do, then we must give them opportunities to construct their knowledge in ways that scientists do" (The Lawrence Hall of Science, 2019, p. 8). Again, this higher-order thinking and thinking as scientists and engineers help students to develop critical thinking skills that will carry beyond the classroom. The concept of asking a thought-provoking question that can lead students on a path of discovery of not just the answer to the initial question but all things surrounding the guiding question. This discovery is more engaging which will solidify the learning that takes place. While phenomenon-based learning is the overarching principle in the new science standards there are multiple aspects incorporated with this learning approach such as the three-dimensional learning. Since these new approaches are a part of the new science standards it will be imperative for educators to understand these methods in order to adequately implement them in their classroom.

## Three-Dimensional Learning

Three-dimensional learning is part of the new framework that is being introduced with the rollout of the new science standards (See Appendix B). The three dimensions are Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Crosscutting Concepts (CCC) (NGSS, 2019). These are incorporated with the phenomenon-based learning approach and make up the new K-12 Science Framework to be used in Minnesota. These dimensions all intertwine during lessons as students explore and observe phenomena while trying to explain and predict. Three-dimensional learning engages students in using scientific and engineering practices that apply cross-cutting concepts as tools to develop an understanding of and solve challenging problems related to Disciplinary Core Ideas being taught (Amplify, 2019). The standards incorporate each of these three dimensions and each lesson includes Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. This approach creates a more authentic learning experience through the integration of phenomenon-based learning and the three dimensions.

**Science and Engineering Practices (SEP).** The SEP consists of eight practices that help to engage students in multiple ways within one curricular unit. Information derived from the Next Generation Science Standard states, “The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems” (Next Generation Science Standards [NGSS], 2019, Three-Dimensional Learning, para. 2). The Science and Engineering Practices are meant to educate students on how to approach and solve a problem versus a skill that they may only be able to apply to one scenario or situation. “The National Research Council (NRC) uses the term practices instead of a term like ‘skills’ to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice” (NGSS, 2019, Three Dimensional Learning, para. 2). There are similarities between the engineering design and scientific inquiry but there are very significant differences that make up the importance of implementing these practices. Scientific inquiry involves the formulation of a question that can be answered through investigation while engineering design involves the formulation of a problem that can be solved through design (NGSS, 2019). The science and engineering eight practices used within the three dimensions are: 1) asking questions and defining problems, 2) developing and using models, 3) planning and carrying out investigations, 4) analyzing and interpreting data, 5) using mathematics and computational thinking, 6) construction explanations and designing solutions, 7) engaging in argument from evidence, and 8) obtaining, evaluating, and communicating information (NGSS, 2019, "More about 3D Learning: Dimension 1: Practices," Box 3-1). Typically, during any lesson more than one of these practices will be utilized. The goal of these practices along with the other dimensions is to clarify the relevance of science, technology, engineering and mathematics to students' everyday lives. At all points of a unit and lesson while the Science and Engineering Practices are in action there are multiple Crosscutting Concepts being utilized.

**Crosscutting Concepts (CCC).** The Crosscutting Concepts are a way of connecting different disciplines and the domains of science. The eight concepts that make up this dimension are patterns, cause and effect, scale/proportion/quantity, systems and system models, energy and matter, structure and function, and stability and change (NGSS, 2019). It is stated by NGSS in regard to these concepts that, "The framework emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world (NGSS, 2019). These eight concepts help intertwine the different disciplines in a seamless way so that students can have a deeper understanding with an authentic learning experience.

**Disciplinary Core Ideas (DCI).** Disciplinary Core Ideas (DCI) are similar to that of the four designs mentioned earlier that were used in the K-12 framework. These four designs have been adapted to be Disciplinary Core Ideas and have requirements in order to be “considered” a core idea. The four Disciplinary Core Ideas are Earth and Space Sciences, Life Sciences, Physical Sciences, and Engineering, Technology and the Application of Sciences (Amplify, 2019). According to the NGSS (2019) website:

> To be considered core, the ideas should meet at least two of the following criteria and ideally all four: Have **broad importance** across multiple sciences and engineering disciplines or be a **key organizing concept** of a single discipline; Provide a **key tool** for understanding or investigating more complex ideas and solving problems; Relate to the **interests and life experiences** of students or be connected to **societal or personal concerns** that require scientific or technological knowledge; Be **teachable** and **learnable** over multiple grades at increasing levels of depth and sophistication. (NGSS, 2019, para. 5, emphasis in original)

These components help categorize the four groups that originally made up the four designs from the K-12 framework which are now known as the Disciplinary Core Ideas. The four groups that make up the Disciplinary Core Ideas are the important areas of the science that have been taught in the past but have been moved around to be taught in a different vertical alignment. These concepts of three-dimensional learning along with phenomenon-based learning all have great benefits for STEM education. The benefits of early exposure can significantly increase the success of students in STEM education when entering middle school.

**Benefits of STEM**

Children are curious and inquisitive in nature, due to the fact that they are learning and making sense of the world around them. Honing this sense of wonderment and curiosity can be a great benefit for STEM educators. Teachers can take advantage of this by really engaging students into their STEM lessons through various student-centered learning approaches. It can create a sense of excitement for learning and a desire for more. Multi-subject integration is very important as it allows for more subjects to be taught simultaneously and allows for stronger connections with the content.

According to Thibaut et al. (2017), there are many studies that show students performing well, if not better, when using an integrated curriculum instead of traditional instruction with separated disciplines. Some may find it surprising that elementary students are in a STEM classroom and working on such activities that involve engineering, but STEM is quite a benefit in an elementary setting. In "Math, Science, and Technology in the Early Grades" by Clements and Sarama (2016), they stated that a lot of young learners arrive with implicit knowledge on science and engineering concepts and that it is quite early that these competencies develop in all STEM subjects (p. 77). Therefore, implementing STEM in an elementary setting is crucial since young learners' interests and curiosities are high. It is also crucial because STEM is helping lay the foundations of problem solving that will help further them in their future learning as well as in real world situations. Capturing students' interest in STEM content at an earlier age only ensures students success through the middle and high school grade levels, so that they will be adequately prepared to enter STEM degree programs (DeJarnette, 2012, p.

77). This will ultimately allow for students to be best prepared for their future classes that incorporate STEM education.

Many STEM lessons and activities are interactive which allows for more engagement by students. This engagement can lead to a more quality experience for a student's educational career. "Much research has indicated that STEM education has a positive impact on students' achievement, attitudes, motivation, and their interest in school" (Thibaut et al., 2017, p. 191). STEM is impactful on student learning since it incorporates so many subjects into learning through real world issues and engages critical thinking. In support Thibaut et al. (2017) state, "Moreover, integrated STEM education has been reported to improve students' higher order thinking skills and technological literacy, making them better problem solvers, innovators and inventors" (p. 191). These learning approaches and discussions can help increase the ability of critical thinking among students, which can be beneficial in other subjects as well. DeJarnette (2012) stated in support of the benefits of STEM education:

> Scientific problem-based activities promote critical scientific thinking and engage students in science. These kinds of lesson activities should not be reserved for middle school and high school classrooms. Elementary students have the cognitive abilities to engage in STEM content and problem solving activities which in turn will whet their appetites for more. Not only do STEM lessons and activities excite young learners, but they also build their confidence and self-efficacy in relation to their own abilities to be successful in more advanced math and science courses in later school years. (p. 184)

Obama expressed the importance of beginning STEM education in elementary since it is crucial for increased success in later school years. Capturing students' interest in STEM content at an earlier age and with a proactive approach can ensure that students are on track in their upper grade levels and be adequately prepared for any STEM related degree programs (Dejarnette, 2012).

It has been stated by numerous sources that relatively few individuals pursue STEM-related careers even though this is an area with significant growth in job opportunities. The importance of students being introduced to STEM at an early age may help increase this number which then would hopefully help fill the high need for workers in that field. Therefore building these solid foundations or interests at an earlier age can help students complete the prerequisites necessary so that they can pursue these career paths later on. DeJarnette (2012) agreed with the importance of STEM education beginning in elementary due to the low numbers in the United States pursuing STEM degree programs.

There is such a high need for talented scientists and engineers within our society. There are rigorous programs for middle school and high school but fewer opportunities for STEM related programs in elementary levels. In current and prior research, it has shown to be beneficial in the impact of perceptions and dispositions of elementary aged students to be exposed to STEM education (DeJarnette, 2012). Therefore, the need for elementary STEM only benefits students' in their future school years especially if a student chooses to seek a higher education STEM degree. Not only will the impact benefit a students' education but the types of learning approaches used in STEM education will help provide for better critical thinking schools that will carry beyond the classroom. In an Amplify Science informational pamphlet (2019), it is stated, “Phenomenon-based learning motivates students by providing them with a sense of purpose and agency, and by engaging their curiosity” (The Lawrence Hall of Science, 2019, p. 8). The engagement through provoking a student’s curiosity leads to a more authentic learning experience.

**Authentic Learning**

Authentic learning is what every educator hopes to provide for their students. Upon research, authentic learning seems to always follow behind a learning approach that revolves around using real-world issues which allows for connections that students can relate to. Using real world issues in the STEM classroom is common practice and also used in the phenomenon-based learning approach. Using real world issues instigates connections for students when they create or find solutions to open-ended problems that connect to some form of phenomena. The phenomenon-based learning approach is to inspire students to ask questions and motivate in-depth investigation (Amplify, 2019). These in-depth investigations and questions formed through the use of the phenomenon-based learning approach help create a more authentic learning experience since it allows for deeper learning. Authentic learning takes place when students are intrigued to continue learning about a specific topic versus feeling as if they “have” to learn what is being taught. Teachers will understand the reason behind learning the various curricula but students may not see the purpose behind it. Therefore, phenomenon-based learning will allow for a more authentic learning experience in which students take ownership of their learning (Amplify, 2019). The same idea is also shared by Herrington et al. (2014) when stated, “Authentic learning pedagogy not only allows students to engage in realistic tasks using real-world resources and tools, but it also provides opportunities for students to learn with intention by thinking and acting like professionals as they address real problems” (Herrington et al., 2014, para. 1). Another goal would be to create critical thinkers that can solve problems by using their scientific knowledge and engineering practices. In STEM for all, an archived article about Obama’s Educate to Innovate initiative:

> In STEM disciplines, the use of active learning not only improves learning outcomes, but also helps to retain students in STEM majors. Active-learning strategies encompass a suite of practices in which students are engaged in thinking or problem solving rather than listening passively to a lecture. These strategies can be as simple as having students challenged to solve problems before a lecture that will provide them with the tools to do so, or can require more dramatic changes, such as engaging students in original research or design in introductory-level courses. (Handelsman & Smith, 2016, para. 5)

The active learning activities within phenomenon-based learning for STEM education will provide for improved learning outcomes. The students are more engaged and the phenomenon-based learning leads to a deep, transferable knowledge. In Finland, according to Symeonidids and Schwarz, this phenomenon-based learning process helped students to become more mindful of their own learning and allowed for students to develop learning-to-learn skills (Symeonidis & Schwarz, 2016). Furner and Kumar

(2007), in support of the authentic learning experience that an integrated approach provides, stated, “A promising approach in this regard, is the use of an integrated curriculum, which provides opportunities for ‘more relevant, less fragmented, and more stimulating experiences for learners” (p. 186). Overall, the process of seamlessly integrating the subjects through the use of phenomenon-based learning proves to create a more authentic learning environment for students. As it has even been stressed in an online STEM education platform that STEM education is crucial to Minnesota’s prosperity as it helps develop the necessary skills for the 21st century worker (Liuzzi, 2020).Therefore, creating a more engaging experience that provides for more authentic learning allows students to hone in on their interest in STEM related degree paths or possible future careers (See Appendix C). Thus, the need for quality instruction and learning approaches within the STEM related fields is a must.

**Summary**

The resources and information found on STEM education and the abundance of different curriculums offer much help in regards to implementing a STEM curriculum within a school. It also brings light to the growth of STEM education throughout the nation and the necessity of STEM education with the growing industries in our economy. All of these factors help influence the need for educators to be provided adequate support with implementing STEM in the curriculum and the benefits of the new learning approaches that will be proposed by the Next Generations Science Standards. It is with this research and continuous training within my current school district on STEM education that I look to answer the question: *How do the three-dimensional learning and* *phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?* In Chapter 3, I will discuss the demographics and setup of my current school district. I will also explain the STEM curriculum that I will create that includes the new learning approach proposed by the Next Generation Science Standards.

# CHAPTER THREE

## Project Description

### Overview

In Chapter 2, much is discussed in terms of what STEM looks like in various schools, the importance of STEM in elementary education, the learning approaches taken, and the benefits of STEM for students. The learning approaches over the years have changed and, currently, the Next Generation Science Standards are under construction to help guide educators on the path of a more engaging and authentic learning approach towards teaching science and STEM. Due to the changes with the Next Generation Science Standards I seek to answer the question: *How do the three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?*

In this chapter, I will explain the reason for exploring and creating a curriculum based on the new Next Generation Science Standards. I plan to use the curriculum developmental process gained from McTighe and Wiggins (2011). The authors stated, "primary goal is developing and deepening student understanding---the ability to make meaning of learning via "big ideas" and to transfer learning" (p. 3). Within this chapter, I provide a project description that details the basis of the curriculum I built and the targeted audience. There is an explanation of my timeline and the setting where the curriculum will be implemented.

**Project Description**

This capstone is a curriculum-based project centered around the three dimensions of learning and the phenomenon-based learning approach that will be applied to a nine lesson STEM unit geared towards first grade. One of the big factors in building this curriculum is using phenomena that embody real world issues in order to create a more authentic learning experience. The phenomenon-based learning approach helps students to identify and create stronger connections with their learning by thinking like a scientist and an engineer. According to Next Generation Science Standards (NGSS):

> There are three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard-- or performance expectation-- and each dimension works within the other two to help students build a cohesive understanding of science over time (Next Generation Science Standards [NGSS], 2013, “Homepage,” para. 1).

The three-dimensional learning and phenomenon-based learning approaches are planned to be implemented in my current school district by the 2021-22 school year. The district’s goal is to do a slow roll-out so that it is an easy transition. The slow introduction of these new science standards will also help prepare the students for the testing that will include questions that relate to the phenomenon-based learning approach. As one of the STEM specialists in this district, I will be teaching half of the standards required for grade-levels first through fifth within my school and will be responsible, alongside my STEM team, to create a curriculum for the STEM classes in my district. I plan to create this curriculum with the support of the information received from my current school district training, meetings, and research in hopes that I can best implement these new approaches in the future. These meetings and training sessions take place each month and will continue throughout the rest of the 2019-20 school year. Another responsibility expected of me is to be the representative for my school to introduce these new concepts and the implementation of the new science standards. Therefore, a deep knowledge of the changes and information on this topic is crucial so that I can best help my team. Building this curriculum will help bridge that understanding for me between these new standards and approaches.

Currently, my students attend STEM once a week for a 50 minute class. Therefore, each of the nine lessons will be 50 minutes in length and will be taught once a week. The nine lesson unit will span over the course of nine weeks due to the fact students attend STEM once weekly. The focus of this curriculum is on energy conservation. Students will be communicating solutions to reduce the impact of humans on land, water, air, and animals. Within each 50 minute lesson, the students will be actively engaged in the phenomena of pollution and the different effects it has on water, land, air, and animals. These lessons will begin by questioning and exploring the concept of pollution and how, as humans, we can reduce the impact of pollution. The students will explore a different type of pollution such as land, water, and air throughout the nine lessons. Animals will be a subtopic within the curriculum since each type of pollution has a direct effect on animals. Students will be able to engage through group work, table talk, partner work, and hands on activities that will help build the connections to what pollution is. The connections made during these lessons will allow students to create solutions with a partner on how to reduce the impact of humans on land, water, and air.

The nine lessons will be created with the new learning approaches in mind, three-dimensional and phenomenon-based learning. The overarching idea in the lessons is the phenomena of pollution. The three dimensions will be applied throughout the lessons and work together to achieve the understanding of human impact on land, water, and air. The Disciplinary Core Idea dimension that will be used for the nine lessons will be Earth and Human Activity which falls under the Earth and Space Science Core Idea. The Science and Engineering Practices to be used is asking questions and defining problems, planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. For the final dimension of Crosscutting Concepts the lessons will be using cause and effect, pattern, and stability and change. Connecting the three-dimensions and the phenomenon to be used for the lessons will help create a starting point for the build of these lessons.

**Curriculum Development**

I plan to develop this curriculum based on the standards outlined in the Next Generation Science Standards. There is a heavy focus on three-dimensional learning, which is also called 3D learning (Next Generation Science Standards [NGSS], 2019, "Three Dimensional Learning"). The three dimensions are Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts. The outline found on the Next Generation Science Standards website will be a huge resource for me as I build this unit. I also plan to follow the guidelines presented within my school district that we are currently being trained in. As I mentioned previously, this will be helpful to my current position as a STEM specialist and the representative for the rollout of these changes. The goal is to become a better educator on all levels and create a better curriculum for my students so that a more authentic learning experience will be provided. The unit I will build for first graders will involve the real-world issue of energy conservation. Again, the unit will consist of nine lessons with each lesson being 50 minutes in length. There will be a gradual build on the different types of pollution as we begin discovering one type of pollution and move on to the next. I will use the Engineering in Education (EiE) curriculum as a support curriculum since that is the current curriculum used in my school district. EiE is a rigorous curriculum that involves engineering in every unit. EiE is a curriculum that was formed by the Museum of Science, Boston and has six design parameters. "These six design parameters include engineering as a unifying theme, units can stand alone, units can be used in order, lessons are flexible and can be adapted to different grades/abilities, lessons are scaffolded, use simple materials, and appeal to all students" (EiE, 2019, para. 2).

The EIE curriculum will not be used fully but only pieces that pertain and connect with the new Next Generation Science Standards. Some of the information from this curriculum will be adjusted and merely used as inspiration for the unit being built.

Another large piece to the curriculum developmental process is the use of McTighe and Wiggins (2011) Understanding by Design (UbD). This design reflects on the combination of two ideas: research on learning, and cognition when pertaining to teaching and assessing for understanding. This guide also offers eight key tenets and has a huge focus creating a curriculum that has the ability to make meaning of learning via "big ideas," to transfer learning, and the curriculum is developed with a backwards building concept. McTighe and Wiggins (2011) stated, "Effective curriculum is planned 'backward' from long-term desired results through a three-stage design process (desired results, evidence, learning plan)" (p. 4). Since it is said that an effective curriculum is planned backwards, I will use this technique in the construction of my unit. The combination of this guide alongside the new Next Generation Science Standards should offer for a successful build of a curriculum.

Throughout the curriculum unit, there are various opportunities for the teacher to gauge the students' understanding. Through the UbD by McTighe and Wiggins (2011) there are two questions that are used in order to determine what is appropriate evidence of students learning. The questions are to determine what specific performance students should be able to do well if the learning is successful and/ or what would have to be seen from the learner to say that goals were achieved (McTighe & Wiggins, 2011). The UbD process focuses on building the lessons backwards, which means beginning with the targeted goal first. Beginning with the targeted goal in mind, I would need to find what evidence I need from the students to best determine their level of understanding. The evidence I use would be in the form of formative or summative assessments. Within my project unit, formative assessments are the completion of the daily activities, checking in with students or groups, and the daily journaling in each student's "Science Notebooks." Summative assessments I plan to use will be the final project for the curriculum unit. The final project will be a poster and presentation of a "Pollution Solution." The students will apply their learning by communicating a solution to a specific pollution of their choice through creating a poster and presenting it to the class. I plan to create a rubric to follow when assessing the students' work. Through the various formative and summative assessments, I will be able to collect evidence from the students, and gauge progress, which will show the effectiveness of the curriculum.

**Setting**

The setting is a suburban K-5 elementary school with a large city population exceeding 63,000 in the area. This school is one of eight elementary schools in the area with 588 students and of that student population only 12% are on the Free and Reduced lunch program. The current academic standing with this school in overall reading proficiency is 72% and in overall math percent proficient is 73%. While the science proficiency percentage of 59% is considered above average the state average sits at 58% in science proficiency. The diversity of students is very low in this school with a breakdown of 86% White, 5% two or more races, 3% Asian, 3% Black, 3% Hispanic, and 1% Hawaiian Native/Pacific Islander. There is a high population of students with autism due to the specialized program offered for students within this area which allows for a higher number of special education staff. The staff at this school is around 24 teachers, 5 administrators, 6 special education teachers, 10 paraprofessionals, and 3 social workers. Students receive their science education by their homeroom teachers, as well as visiting STEM once a week. Grade level teachers are expected to split the current science standards between themselves and the STEM specialist.

**Timeline**

The completion of my capstone project is May 2020, which is my last semester at Hamline University. Throughout the final semester, I plan to develop and adjust the curriculum so that it can better serve my students and fully incorporate the three dimensions and the phenomenon-based learning approach. The curriculum unit will be based on nine lessons that will present the real world issue of energy conservation. It will engage first grade students to think like scientists and engineers to help solve problems associated with energy conservation. Each lesson will be influenced by a question regarding the phenomenon of pollution. The unit will include researching and reviewing evidence from multiple sources, will be hands on, and the final portion of the unit students will piece together their discoveries to find the solution to the problem.

The other part of my timeline is to implement the created unit in my personal classroom prior to the rollout of the new standards. The goal would be using these new learning approaches to see the learning impact within my own classroom. There would be an end of unit assessment that could help gauge if the learning targets were met and if they were met at higher success rates than previous years. The results of the assessment would be useful in discussion at our professional development meetings for the District Science Leadership Committee. It would provide me with adequate information to provide insight on the new standards that we will implement district wide. It will also provide me with the tools to guide fellow teachers in my school to begin these new standards as well as prep me for the full rollout of the new standards in my own classroom.

## Summary

The major aspect of Chapter Three is introducing a nine lesson curriculum project using the Next Generation Science Standards which are to be carried out in Minnesota schools the 2023-2024 school year. The nine lesson unit geared towards first graders will tie into real world phenomena such as energy conservation. The goal is to get better acquainted with the new standards and approaches so that I can best implement them in my classroom, and answer my question: *How do the three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?* In the upcoming chapter, I will expose a deeper look at the curriculum development, process, learning approaches, and information found during my research.

# CHAPTER FOUR

# Conclusion

## Chapter Overview

The goal of my Capstone project was to create an effective STEM unit plan and to answer the research question: *How do three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?* I created a nine lesson unit plan with the use of three-dimensional learning and the phenomenon-based learning approaches. These lessons were adapted through the new standards being proposed by Next Generation Science Standards (NGSS, 2019). The new learning approaches are to be implemented within these new science standards and incorporate an influential presence of STEM education. My lessons were developed using the McTighe and Wiggins (2011) backwards design framework.

Chapter four focuses on the curriculum building and process for creating my Capstone Project. First, I discussed my major learnings throughout this process and the literature review that influenced my unit plan. Second, I discussed any implications and limitations of my Capstone project. Then, I touched on what further research I can do to help advance my learnings in this subject. Finally, I addressed how I plan to communicate my results from the project and how this project can benefit educators.

## Major Learnings

The Capstone writing process has been beneficial to me for many reasons. One being that I have been able to jump back into the world of academic writing and APA format. Writing is not my strong suit; therefore, this process has been predominantly challenging. While challenging, this process has allowed me to brush up on these skills and become better acquainted with the APA format. This entire process has provided me with stronger skills in research, lesson design, and writing that I can now present in my classroom.

I have also found that I am better acquainted with the upcoming science standards that implement the two learning approaches: three-dimensional learning and phenomenon-based learning. Learning more about these learning approaches helped me to see how they are beneficial in the classroom when it pertains to an authentic learning experience. Three-dimensional and phenomenon-based learning approaches allow for students to make connections in multiple ways (The Regents of the University of California, 2018). Not all students learn the same and therefore having learning approaches that help fit the needs of the various learning levels is crucial.

Gaining a stronger knowledge of the learning approaches also helps me to create stronger connections in my district meetings. As a member of the District Science Leadership team, it is useful that I have strong knowledge of this topic. The better understanding of three-dimensional and phenomenon-based learning approaches will help me to be a better educator when implementing the new standards within my classroom.

Another major learning is the use of the backwards design by McTighe and Wiggins (2011). The process of building from the end result goal had helped me tremendously in terms of lesson building. I find it to be crucial to start with what results you are looking to gain from a lesson before creating the actual lesson. It is necessary to first know what desired results you need and what would be considered acceptable evidence before creating activities for a lesson (McTighe & Wiggins, 2011). This form of lesson building aligns very well with three-dimensional and phenomenon-based learning approaches. Since these learning approaches are student led with teacher guidance, beginning the lesson planning process with the end result in mind would be critical. I found that when first brainstorming my potential lessons my mind became overwhelmed. It mostly became overwhelmed in thinking of the various ways my lessons could go using the three-dimensional and phenomenon-based learning approaches. It was the use of the backwards design that allowed for my lessons to take shape.

**Literature Review**

The literature review helped me tremendously in regards to creating a more solid connection with the goals of three-dimensional learning and phenomenon-based learning. This is imperative since I am already involved on a team that is currently learning these approaches. There is so much depth to three-dimensional learning and phenomenon-based learning, and they require solid understanding in order to properly implement them in the classroom. Currently, in our District Science Leadership meetings, we are discussing what exactly three-dimensional learning and phenomenon-based learning are and how they will look in the classroom. This process through the district has been rather lengthy and will span over the course of this school year and next.

Three-dimensional learning and phenomenon-based learning approaches are student centered, which means the students lead the lesson through their questions about a specific phenomenon (The Lawrence Hall of Science, 2019). While students lead by questions, it is important that the teacher is able to guide students along the path to the end result. The end result is that through a student's own research, which requires them to act like scientists and engineers, the students will build a more concrete understanding of the subject (NGSS, 2019). This understanding allowed me to remember that when creating my unit plan, in order to encompass the three-dimensional and phenomenon-based learning approaches I need to begin with a thought-provoking idea that would lead to questions. These questions could then lead the students to work through an activity where they come to find the answers or "end result." This process will allow for students to be more engaged and feel more responsible for their own learning.

**Implications**

One significant implication is the implementation of the three-dimensional learning and phenomenon-based learning approaches within a school's science education. This implementation has already been addressed in our school and there has been great concern from our educators. The information regarding the new science standards and these new learning approaches have only been introduced in small amounts. While there is a goal of slowly rolling out these new standards, it still feels like a heavy burden on the staff at my school. I would only imagine the same sentiment is shared at other schools within my district.

I can understand why this may feel like such a heavy burden to take on being that it requires a lot of guidance to understand the implementation of the new science standards. Teachers are expected to teach in a whole new fashion and add more time for science education in their already full day of academics. My project may be provided as a great example as to what using three-dimensional and phenomenon-based learning looks like in a classroom. Providing teachers with curriculum examples would be useful, but teachers may still come with reservations on the implementations of the new science standards.

**Limitations**

Some limitations that may be found is that some educators feel as if they do not have enough time in the day to incorporate a lengthier science instruction. Currently, some schools may not have a block of science education within their daily schedule and these new standards require daily science instruction. This may prove to be a daunting task for our educators.

Another limitation is that not all schools are equipped to take on these new standards because they would require a great deal of professional development. Our district is taking the approach of having a leadership team become strongly knowledgeable on the new standards and learning approaches so that they can assist in the rollout at each school. Not all schools have the resources to provide proper training for their educators. It may also be difficult for some schools to have the proper curriculum and materials needed to implement a proper lesson that incorporates three-dimensional learning and phenomenon-based learning approaches.

**Future Research**

Future research to be considered is what proper professional development would look like for educators in terms of helping to implement the new standards that incorporate three-dimensional learning and phenomenon-based learning approaches.

Other research on what are good resources and curriculums to use in the classroom would be beneficial for schools and educators.

There are quite a few programs and companies out there that offer curriculum resources with materials for the new science standards. These programs and companies offer similar resources and tools but proper research would help aid schools and educators on what would work best in the classroom.

I also think there can still be further research on the new science standards as well as three-dimensional learning and phenomenon-based learning approaches. Even after this Capstone, I feel there is still more to learn. Gaining more knowledge will only help me as an educator implement these new concepts in my classroom.

**Communicating Results**

As I have mentioned previously, I am a part of a District Science Leadership team where we are preparing for the implementation of the new science standards that incorporate three-dimensional learning and phenomenon-based learning approaches. At this time, we have only been able to touch on the two learning approaches and begin a breakdown of the new standards. The breakdown of the new science standards has been beneficial, but the research of this Capstone has made me more knowledgeable in my meetings. It has also helped build understanding of the new information being presented in each meeting. This understanding has allowed me the ability to help fellow teammates in our meetings and at our site meetings.

There can be a lot of questions as we navigate the new science standards and having done this Capstone project, I am able to share an example of what we are working towards. I can also share my Capstone project results with fellow educators at my school site so that they can best understand what exactly three-dimensional learning and phenomenon-based learning looks like in a classroom. Right now, providing as many resources and examples of these approaches for our educators is beneficial as there is a lot of expressed stress with the new science standards.

**Benefit to Educators**

My hope for my Capstone is to benefit educators with providing an example framework for what the new standards could look like in lesson form. Educators being able to review my lessons that incorporate three-dimensional learning and phenomenon-based learning approaches will help build a stronger connection to using those approaches in the classroom. Since there has been expressed fears from our educators on how these new standards can be utilized in the classroom, the example lessons help provide a visual of how it can be done. This Capstone project can provide a stepping stone to understanding.

**Conclusion**

Chapter four summarized the process of creating a STEM curriculum that incorporates three-dimensional learning and phenomenon-based learning to answer the research question: *How do three-dimensional learning and phenomenon-based learning approaches increase the authentic learning experience for students in elementary STEM classes?* In this chapter, I have addressed what major learnings I have gained from this process. I discussed my literature review and how that helped guide me in the Capstone process as well as in my current educator role. I also discussed the implications and limitations of my project. Finally, I addressed how I would communicate the results of my project, and what benefit my project can bring to educators.

The Capstone writing process has allowed for a tremendous amount of growth for me in more ways than one. I feel that I have grown as a student and, most importantly, as an educator. I feel better equipped to provide better lesson building for my students. I am also thankful for the knowledge I have gained through research on three-dimensional learning and phenomenon-based learning. This understanding is crucial since it will soon impact my school and current role. It will also help me to better assist my fellow teammates since I will be looked to as a resource during the implementation of the new Next Generation Science Standards from being a member of the District Science Leadership Team. My hope is that the curriculum I have built will be a good resource for my teammates when looking for guidance on implementing the new standards.

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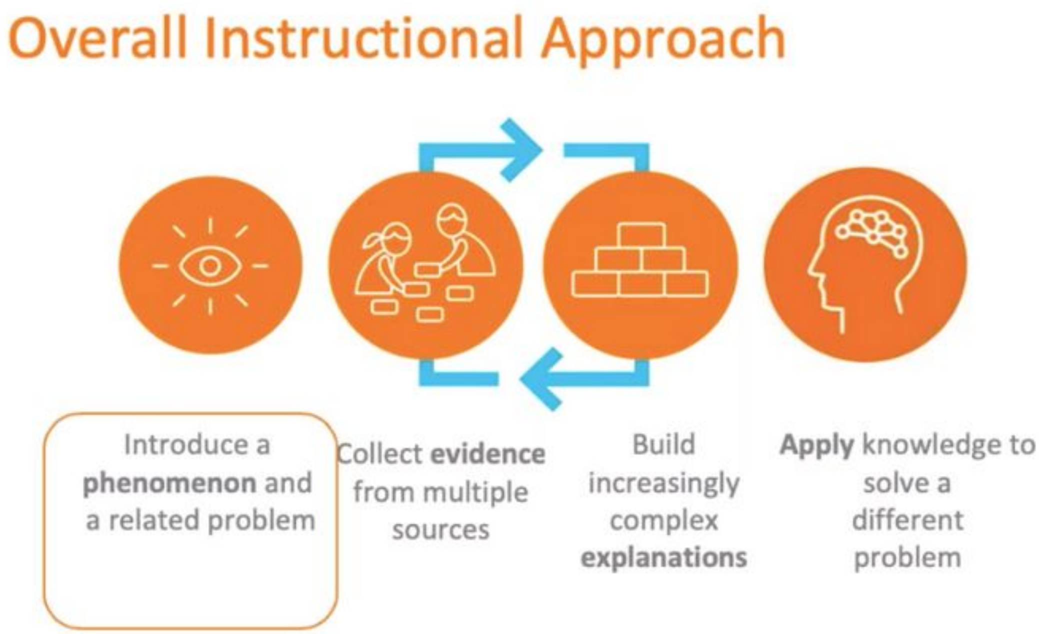
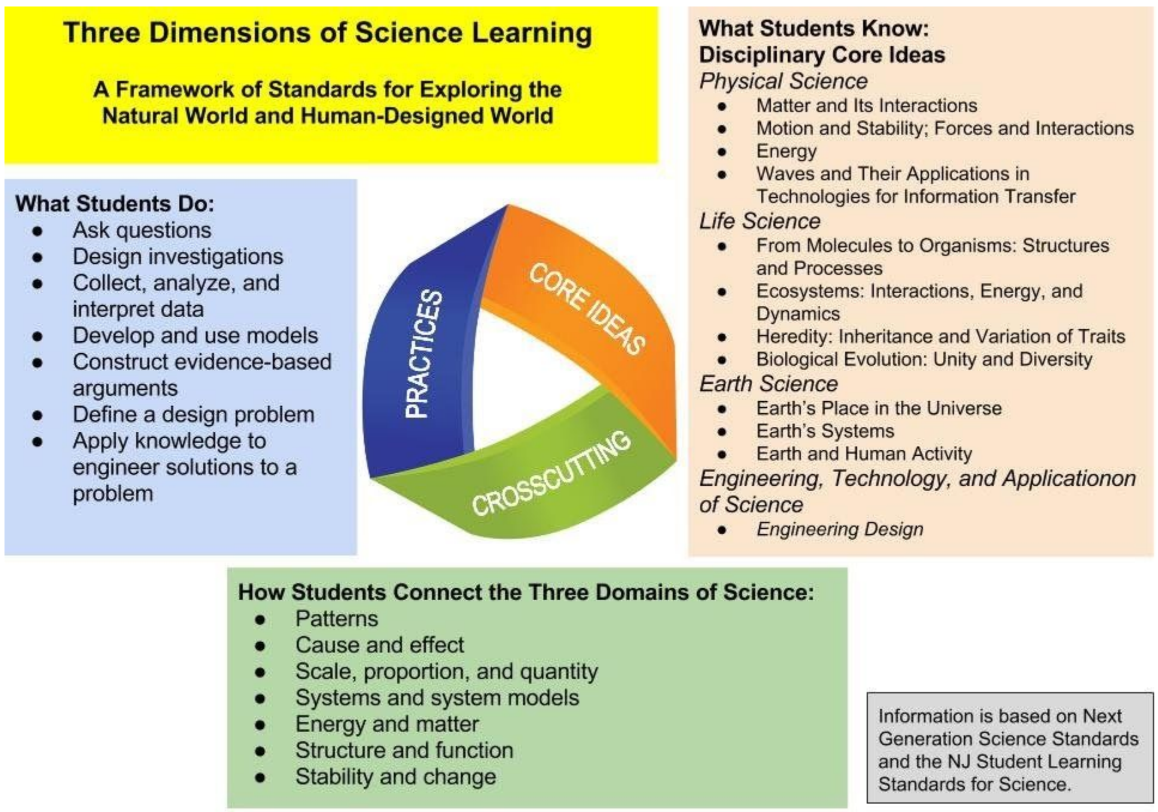
APPENDIX A- Overall Instructional Approach



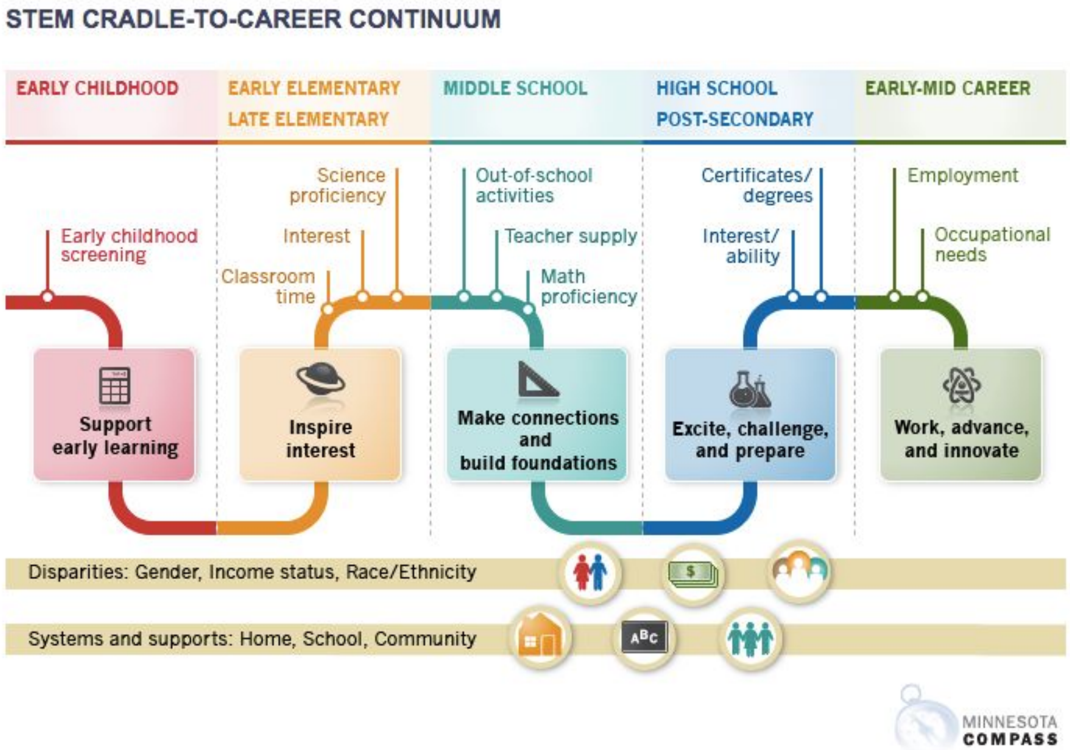

(Amplify, 2019)

# APPENDIX B- Three-Dimensional Learning




(Chen, 2016)

APPENDIX C- STEM Education to Career




(Liuzzi, MNCompass, 2020)