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Foundational Elements Of A Steam Learning Model For Elementary School

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FOUNDATIONAL ELEMENTS OF A STEAM LEARNING MODEL FOR ELEMENTARY SCHOOL

by

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To Breccan and Teague,
for teaching me the values of
patience, persistence, and empathy.
I love you.

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CHAPTER ONE

Introduction

Overview

As an educator, I have observed that students can be remarkably excited to explore the world around them; I have also observed students' interaction with the world around them defined by what others decide they ought to be learning, thus stifling some of that natural curiosity and drive to build new knowledge. As a student, I had many teachers that expected me to quietly listen during lectures and then memorize and recall the information conveyed to me. I experienced learning as separate sets of skills and ideas that didn't have much connection. The first teacher who I remember pushing me to think past these boundaries was my 7th grade science teacher who posed problems for students to solve, and would answer questions with more questions to get students to come to their own answers.

Only as a new teacher did I reflect on this experience and think about how it might have influenced my learning philosophy. For most of my own education with a few notable exceptions (including 7th grade science), isolated subjects, quiet reading, completing worksheets, and taking tests was the norm. However, what I really thrived on as a student was the chance to create something--a science fair project on the rate of mold growth on various unrefrigerated foods, a woodworking project that looked like a woodpecker and functioned as a doorknocker, or a solar cooker that just barely heated cookie dough on a warm spring day. Being an active participant in the learning process motivated me to want to read, write, solve problems and talk about what I was learning.

I think that since I've realized these things were important to me as a learner, I have been more conscious of trying to structure the learning experiences in my classroom around what I hope will engage students and also what will be relevant to them throughout their lives; I want students to see learning as more than what happens within the four walls of our classroom. In the current reality of information at your fingertips, worksheets and reading logs are not engaging or motivating. I want more for my students, and I believe that even given the current educational climate which emphasizes test scores as markers of student progress and achievement, a STEAM learning model can enrich the elementary school learning experience in such a way that students begin to see learning not as a chore, but as a lifelong pursuit of new ideas.

Professional Context

As a science teacher, I wrote and implemented an inquiry based science curriculum with kindergarten students. I used a learning cycle that began with asking a question, then making observations, then exploration and discovery, then sharing of what they learned ("wonder, observe, discover, share"). In the process of teaching science, I grew to love science more than I'd ever imagined. Since then, I've moved on to teach third grade, and I have the desire to integrate more of the work I was doing with science into my classroom during math and literacy. I want students to see that the skills, concepts and strategies they are learning in these areas do not exist in isolation; I also want to structure the learning so that I am a facilitator of inquiry and students have more ownership of their learning.

My sense is that it is possible to implement elements of a STEAM learning model within the instructional day, but to really do justice to this type of learning all of the elements have to be thoughtfully structured with a specific goal or goals in sight. A STEAM learning model integrates the subject areas of science, technology, engineering, arts and mathematics and builds students capacity for seeing connections between topics and using skills like collaboration, critical thinking and inquiry to delve deeply into finding answers to questions or showing their knowledge in inventive and unique ways.

For much of the academic day, I feel that my student's exposure to integrated content requiring them to approach learning as critical thinkers seems limited due to standards being taught in isolation. My goal is to identify the foundational elements that I believe are integral to successfully planning and implementing a STEAM learning model in the elementary school classroom. My district has implemented STEAM classes at the middle and high school levels, and has been in conversation about how best to introduce STEAM learning to students at the elementary school level. As a classroom teacher, my goal is to foster similarly integrated learning throughout the regular school day for my third grade students. In developing a structure for a successful STEAM curriculum, I first need to consider the foundational elements for learning in this type of environment. I will address the question: What are the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom?

Foundational Elements of a STEAM Learning Model

Inquiry. As I think about integrating content through STEAM learning during the school day with my third-grade students, I know that I want the work they are doing to be authentic. I want students to be doing more than keeping a journal of information that will be recycled at the end of the school year; I think students should have an engaging reason and purpose for the work they are doing during the school day that goes beyond their teacher reading the work that they have written (whether on paper or digitally) and giving them feedback.

The district in which I work has developed a literacy narrative for the elementary schools as they progress toward a full Balanced Literacy implementation over the next few years. I think it is applicable to a STEAM learning model as well because it highlights some of the elements that are foundational to students engaging in integrated content:

The Mounds View literacy experience will foster lifelong readers and writers who engage in real reading and writing for real purposes. Students will be engaged in authentic reading and writing, worthwhile literacy tasks and accountable conversations across all content areas. All students will see themselves as readers and writers and value their continuous growth in those areas. (Mounds View Public Schools 2015)

My intention in including this narrative is to highlight the language of authenticity and literacy in connection with STEAM learning. I'm especially attracted to the words "real reading and writing for real purposes" and "accountable conversations across all content areas" because I see these things as particularly instrumental in establishing a culture of deep learning and community within a classroom. I also think that this narrative can be extended into a STEAM learning model because the concept of literacy goes beyond simply reading and writing. Authenticity can and should be considered in any content area that is shared with students so that they can begin to see real world connections between topics and ideas. Authenticity in my teaching means that as a teacher I am responsible for making those connections clear, and that students can see how the things they are being asked to do are relevant or meaningful to their lives or the lives of other people in the community.

When I think about STEAM learning, I connect right away to the inquiry cycle that I used in teaching science that encouraged students to think for themselves and ask or answer questions independently with my guidance. I value creating a lesson that starts with a question and leads students gradually to understanding the topic in question, and potentially results in them asking more questions related to the topic. Problem solving and critical thinking are essential within STEAM learning because students are not doing work in which they have to provide a correct answer or repeat what someone else has already done. Students are being asked to analyze, reason, evaluate, solve problems and make decisions about ideas and how they are related to the world around them.

Being purposeful in planning questions that can address student misconceptions and also enrich students thinking who have already grasped the essential understanding is crucial to facilitating students critical thinking during STEAM learning. Also, it is important to be able to meet students where they are at in their progress in the moment and ask questions that can scaffold them to further evaluate the work that they are doing.

Being intentional about framing the lesson and the path I want students to traverse over the course of their learning will help me in developing lines of questioning and also to know when or how I can be creative in facilitating critical thinking throughout the learning cycle.

21st Century Skills. By focusing on the habits of critical thinking, communication, collaboration and creativity during STEAM learning I can support students in developing their skills in both a social and academic context. As our society leans more and more toward valuing these habits in the workplace, as a teacher I feel it is my responsibility to effectively structure learning opportunities that require students to actively listen to their classmate's perspectives, learn to work as a team and give constructive feedback to each other.

Critical thinking connects closely with using inquiry as a basis for beginning a unit of study, because students begin the conversation with what they know, and then make connections or draw conclusions based on communications that they have with their classmates, teachers or others involved in the learning (parents or community experts, for example). Student collaboration can support valuable social skills, help to foster interpersonal relationships, improve student attitudes toward one another, and require students to learn from each other. When students have the opportunity to demonstrate their learning in inventive and original ways, they are able to think creatively about the information they are working with and how best to show what they want to express by whatever means is appropriate for the given lesson or unit of study. Sharing ideas can lead to more questions or an insight to explore a connected topic.

Learning to communicate clearly about what they are learning is an important social skill as well. Being able to think critically about a topic, work with others to address a problem or idea, communicate what is learned from the inquiry and subsequent work, and creatively present that knowledge is at the root of learning in the 21st century.

Digital Citizenship. I want to get to a point in my classroom that technology is used to transform the way that learning takes place rather than being a substitute for tasks that could otherwise be done with regular texts, papers and pencils. I see the opportunity for students to create rather than simply absorb content with the use of many of the tools that are available to students because of the technology in our classroom. I see digital literacy in connection with another foundational element to STEAM learning mentioned above: authenticity. The simple truth is that the world is at our fingertips every time we turn on a screen; the challenge as a teacher of third grade students is how to make connections to the world that demonstrate to students how to be responsible digital citizens and allow them to connect with and share their thinking with a broader community. I am also excited to explore the ways in which I can use technology to connect with families to support student learning throughout the school year. I look forward to integrating the technology tools and resources to which I have access in a way that supports students in modifying and redefining their learning.

Learning Partnerships. With all of the digital tools and programs available to students and teachers, I think that addressing how learning can connect students to their community (whether local or global) is another important consideration in developing units of study in a STEAM learning model. A whole unit of study could be shared digitally, from the questions that spark the project to the final product of students learning; sharing their work with people beyond the classroom holds students accountable and hopefully motivates them to put in their best effort.

Setting up a Google hangout with professionals in various fields of study allows students have conversations with people about their work. A virtual field trip gives students glimpses of places that they might not otherwise have a chance to experience. Setting up these types of experiences may be time consuming, but I just continue to think about the possibility of inspiring students to connect what they are working on in their classroom with real people in the world, and seeing that what they are doing has meaning. Students might even have the chance to work collaboratively with another group of students outside of their own school, and see a perspective different from their own.

Having students work on a STEAM project that will be shared with another community outside of the classroom provides a valuable means of assessing students learning across content areas, from the process of gathering information to deciding how best to share the results of their learning. Parents and families can be a part of the learning that their children are doing during the school day, and through that connection be better able to support their students in their goals.

Another aspect of learning partnerships that I feel will be instrumental to developing a successful foundation for a STEAM learning model is collaboration between teachers and staff around what it looks like to build up the foundation for students to be comfortable with taking the risk involved in participating in work that might be new or different from the educational structure with which they are likely familiar. Through open, honest conversations around professional development, sharing strategies for teaching and being willing to try new ideas, a PLC (professional learning community) can come together around the process of aligning standards and planning lessons or units of study that engage students in STEAM learning while ensuring that they are also progressing toward grade level learning targets.

Summary

The goal of my work is to address how teachers can foster the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom. With this foundation in place, teachers can focus on designing STEAM lessons or units of study that capture interest and capitalize on the skills and concepts that are inherent to inquiry, critical thinking, collaboration, communication, creativity and digital citizenship. Also, I will emphasize the importance of forming positive partnerships with teachers and staff, families and community experts in order to enrich student's learning experiences and share ideas that can benefit everyone involved in the learning.

In Chapter Two, I will address the current literature on each of the foundational elements I discussed above and how I see them as instrumental to structuring a successful STEAM learning model in the elementary school classroom. First, I will provide a working definition of STEAM and discuss its development over time and potential for enriching student learning. Then, I will connect inquiry, the 21st century skills of critical thinking, communication, collaboration, creativity and digital citizenship to a STEAM learning model. Finally, I will address how learning partnerships between teachers, parents and community experts can support students and enhance their education.

CHAPTER TWO

Literature Review

Overview

In reviewing the literature, my goal is to address the question: What are the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom? I will begin with a brief discussion of STEAM learning in order to frame my vision for a foundational curriculum that is flexible and responsive to diverse students and this rapidly changing world. Rather than delineating a set of lessons or specific units of study, I will address how teachers can foster foundational elements that are integral to successfully implementing a STEAM learning model in the elementary school classroom: inquiry based learning, 21st century skills, learning partnerships and digital tools. Within these elements, I will discuss the components that make them important to fostering STEAM learning that is authentic and applicable across the subjects of science, technology, engineering, art and mathematics.

What is STEAM?

In education, STEAM is an integrated approach that incorporates the subjects of Science, Technology, Engineering, Arts and Math as a means of developing student inquiry, communication and critical thinking during learning (Riley, 2014). This is an adaptation of STEM, which highlights the connection of two or more content areas to guide instruction through observation, inquiry and solving problems (Riley, 2014). Furthermore, STEAM is not a single curricular area, rather, it is an approach to connecting and deepening each of the curricular areas that it addresses by integrating the standards that are a part of each individual area and shifting learning behaviors and environment to support students achievement of targeted standards (Riley, 2014).

Addition of the "A". The addition of arts to the STEM learning model reflects society's increasing focus on innovation and design as integral to these fields of study. Children deserve to have rich experiences across a wide range of disciplines, and artistic skills, creativity and curiosity are in high demand when a project is focused on the visual and performing arts--from narrating a film to making a robot dance (Martinez and Stager, 2013). In a STEAM curriculum, it is clear that "arts and sciences do not compete, they are complementary. The arts create a very subjective view of the world, while science creates an objective view of the world. More original thoughts and creative processes result when counterparts of the brain interact. A person's brain needs both views in order to make suitable decisions" (Sousa and Pilecki, 2013).

Also, art emphasizes careful observation and detailed description just as science does- these disciplines have many similarities in learning how to communicate knowledge effectively. The arts play an important role in nurturing better communication skills and critical thinking abilities, as well as developing a global perspective (Conley, Douglass, Trinkley, 2014). While STEM subjects encourage integrated learning, "Combining the arts with STEM means that children can express themselves in even more variations" (Martinez and Stager, p.55, 2013). Adding a focus on art allows for even more opportunities for students to create, design and innovate.

Integrated Content. As educators, we are responsible for making sure that students are doing work that is aligned with standards. “the Common Core State Standards’ (CCSS) emphasis on real-world application of knowledge and skills, push for competencies in critical thinking, use of relevant technologies and media, and focus on student collaboration fit well within the framework for STEAM education” (Maslyk, 2016, p.17). In order to balance a focus on standards and foster inquiry within a STEAM learning environment, there must be an intentional plan in place to assess student-driven learning--ideally, one that students have had input on and have been exposed to prior to starting their work. (Boss and Krauss, 2014). This type of assessment not only gives students a context for their expectations during the work and on the finished product, but it gives the teacher insight into the student’s development toward desired learning targets. In planning for units of study in a STEAM learning environment, the Next Generation Science Standards (NGSS Lead States, 2013) also give insight into the planning process and what important elements should be included. With regard to performance expectations, students are expected to show proficiency in asking questions and defining problems; developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NGSS, 2013). These skills highlight the importance of thinking critically and creatively, and so the NGSS are essential to the implementation of a successful STEAM learning model.

Taking a STEAM approach to learning requires teachers to identify areas across the curriculum that can be aligned, taught and assessed together for greater impact on students learning (Riley, 2014). An integrated learning model allows teachers to frame subject matter to be taught in a manner that accurately reflects the world, as most problems do not fit neatly into compartmentalized subjects (Conley, Douglass, Trinkley, 2014). A STEAM learning model encourages students to use what they know to seek answers to questions previously unasked or to share ideas and work together toward a creative solution.

STEAM brings together the critical components of how and what, and laces them together with why. Think of STEAM as teaching through integrated network hubs where information is curated, shared, explored and molded into new ways of seeing and being through collaborative risk taking and creativity. This means that students are using the skills and processes learned in science, technology, engineering, the arts and mathematics to think deeply, ask non-Googleable questions and solve problems. (Riley, 2014, p.23)

Science, engineering, and technology are woven through nearly every aspect of modern life, and they are instrumental in meeting many of society's most pressing current and future challenges (National Research Council, 2013). Therefore, it is our responsibility as educators to recognize that we are preparing students to succeed in a world that is constantly changing.

A STEAM learning model that is built on the foundational elements of inquiry, 21st century skills, digital citizenship, and learning partnerships does more than teach students the importance of science, technology, engineering, art and math- it shows them that they can think and work like scientists, engineers, artists and mathematicians and that their work is not prescribed or fixed, but fluid and changing.

Summary. My goal is to suggest structures for the development of a STEAM learning model in the elementary classroom by starting with the foundational elements that encourage both teachers and students to look at education in a different way. I will highlight these themes:

- inquiry based learning
- 21st century skills
- digital citizenship
- learning partnerships

These elements are foundational because they need to be developed in order for students to get the most out of an integrated learning experience in an authentic and applicable manner.

Inquiry Based Learning

What makes learning authentic to students? In order to reach students in a meaningful way, it is important to be cognizant of the fact that they each enter an educational setting with their own schema. In designing a learning experience that will connect and resonate with students, teachers need to find meaningful ways to integrate STEAM into their daily work (Maslyk, 2016, p. 11) as well as connecting with events that are taking place in the world around them to create a framework for inquiry. Teachers can guide students with essential questions, or big ideas; then, students should have the opportunity to discuss ideas, ask their own questions, explore, problem solve, and create within this framework.

This goes hand in hand with an authentic assessment of student's efforts from both a social and academic perspective; formative and summative assessment of student mastery of the integrated learning objectives should be done in a way that allows for student creativity, choice and individual voice to be a part of the process.

The 5E inquiry model requires students to:

(a) engage in inquiry topics and questions, (b) explore the inquiry methods and processes, (c) explain the inquiry analyses and outcomes, (d) evaluate the inquiry processes and outcomes and (e) extend the inquiry topics and questions. The process is cyclic and progressive but not linear, and may not involve all of the components in each learning cycle. (Kong and Song, 2014, p.129)

Developing Essential Questions. Incorporating inquiry into the learning environment is a way to support student centered learning and requires intentional planning and modeling by the teacher. "Although open inquiry provides optimal opportunities for students' cognitive development and scientific reasoning, teacher guided inquiry may provide better opportunities for students to focus on the development of particular science concepts" (Kong and Song, 2014, p.129). By first modeling and training students with a whole group inquiry lesson, students become familiar with the process of asking questions and using the question to direct their learning process. "Inquiry based learning includes three approaches: structured, guided and open inquiry, listed in ascending order of the learner's autonomy over setting investigation problems and planning problem-solving procedures" (Kong, Song, 2014, p.128). A gradual release model for learning such as “I do, We do, You do” can support students in being able to ask questions independently in small groups or individually.

To build a foundation for a STEAM learning environment, these essential questions should be grounded in more than one subject areas. In breaking down the barriers that are traditionally placed around subjects, teachers can support learning for students that are creative and logical-mathematical in their thinking, making the learning more personal and allowing students to connect to the content (Maslyk, 2016).

Student motivation (choice, ownership, agency). We need to operate as if students own the time in our classrooms, not us. Kids rise to the occasion if we let them. When students own the learning process, they also own the knowledge they construct. Self-reliance results when we relinquish control and power to our students. (Martinez and Stager, 2013, p. 70)

Google gives their employees what they call 20 percent time, in which they get to pursue a project that is not necessarily related to their job. These “passion projects” ensure that employees have a creative outlet for their work, and have a chance to learn about something that truly excites them (November, 2012). The same philosophy can be transferred to an elementary school STEAM learning model to give students the time and space to feel ownership of their own learning process and agency in what they are choosing to learn about. Effectively making this transition requires a shift in our understanding of student motivation as well as our expectations for student engagement and collaboration (November, 2012). If students feel passionate about their topic of choice, the likelihood that they will be intrinsically motivated to do their best is increased

(Boss and Krauss, 2014). And, it's still possible to informally assess students on core research skills emphasized by the CCSS when students choose a topic of their own on which to focus their energy and time.

To foster student agency, it is crucial to have a classroom space that is organized to encourage student ownership and participation throughout the learning experience (Edson, 2013). One way to do this is to make sure that students have access to any materials or resources they might need during a specific unit of study; another is to ensure that there are clear expectations and limits in place so that students understand which materials and resources they are able to use (Edson, 2013). "Materials, tools, and resources are crucial, but the teacher's job is to keep the spirit and mood of the space conducive to creativity" (Martinez and Stager, 2013, p. 157).

Summary. A foundation in inquiry is important to the successful implementation of a STEAM learning environment in the elementary school classroom because of its focus on digging deeper into ideas and thinking critically about topics of study. Once students are familiar with essential questions, they will be more comfortable with open ended inquiry and exploring their own ideas by developing questions. To maintain progress toward specific academic goals structured around STEAM standards, teachers can intentionally plan the focus for each unit of inquiry and students can develop questions connected to that topic.

21st Century Skills

One benefit of introducing a STEAM learning model in the elementary school classroom is to engage students in the practices of critical thinking, collaboration, communication and creativity- not just through an isolated task, but with the goal of creating something useful or coming up with a solution to a social problem. Working with an inquiry model, students understand that the goal of their learning is to ask questions, investigate, make new discoveries and share their thinking with others. Rather than meeting an end, they might come up with another question and begin the process of researching again. Innovation is embedded in this work, so that students know their learning has a purpose beyond completion of a task or a grade from their teacher.

Critical Thinking and Problem Solving. Whatever the nature of the work, "teachers watch how their students explain ideas and gain insights into the way young minds perceive those problems" (November, 2012). Taking the time to listen to how a student explains their thinking can uncover a lot about their understanding of a topic, and give the teacher a place from which to scaffold their knowledge.

When children are allowed to think through problems, they may invent different paths to a suitable answer. The purpose of school should be to encourage children to develop such skills. Instead, we spend a lot of time telling children they are wrong, and then expecting them to accept that rejection and cheerfully try again. A teacher who allows a child time and support to rethink and revise gives a child autonomy and the ability to trust themselves to be problem solvers, even if their path to success is different than everyone else's. (Martinez and Stager, 2013, p. 71)

The Columbus Museum of Art uses a model for art exploration to foster critical thinking that involves four steps: observe, describe, interpret, and prove (Conley, Douglass, Trinkley, 2014). Through observation, patrons "engage in systematic, deliberate study" (Conley, Douglass, Trinkley, 2014, p. 92). In describing the artworks, the thinker is challenged to "parcel out what is known versus what is perceived" (Conley, Douglass, Trinkley, 2014, p.92). Interpreting the work requires participants to "reframe their thinking based on the input of their peers" and consider multiple explanations while addressing the significance of the artwork (Conley, Douglass, Trinkley, 2014 , p. 92). Finally, participants work collectively or as individuals "to develop a summative statement or argument about the work" (Conley, Douglass, Trinkley 2014, p. 92), with the reminder that there is not a single right or wrong conclusion at which to arrive .

This model of observation, description, interpretation and proving (ODIP) is beneficial to developing critical thinking skills and can be used in exploring the integration of art and mathematics; ODIP provides students with a structure for developing a narrative of their thinking that shows abstract reasoning, examination of multiple aspects of a problem and construction of a sound argument (Conley, Douglass, Trinkley, 2014). This model echoes the Standards for Mathematical practice that reflect the importance of "advocating for a variety of classroom processes such as communication, representation, and making personal connections" throughout students work in mathematics (Conley, Douglass, Trinkley, 2014, p.91).

Collaboration. In addition to having a positive effect on academic achievement, collaboration can support valuable social skills; it helps to foster interpersonal relationships, improve student attitudes toward one another, and gives students the opportunity to learn from each other. Additionally, "when cooperative learning is used in the classroom, students are more accepting of diversity and have a greater sense of independence and responsibility for their learning" (Gardner, 2012, p.62). Collaboration with their peers presents students with the task of actively listening to their classmate's perspectives, learning to work as a team and giving constructive feedback to each other. Furthermore, "students teaching students is a powerful method for building learning and drawing creativity and innovation" (November, 2012, p. 26). Students are eager to attend to information shared by their peers; it then becomes the responsibility of the teacher to carefully monitor student conversations for accurate and valid information.

A factor to consider within collaborative work is how to track student participation and ensure that all students in the group are contributing to the learning; one way to do this is to assign each student a role within the group, another is to have an individual product that each student is responsible for completing. One approach is to "have students reflect on and critique their own and peers work with self- assessments, rubrics, portfolios, artists' statements, or peer reviews" (Riley, 2014, p. 33).

<u>Communication.</u> Why is effective communication important to a STEAM learning model in the elementary school classroom? Learning does not happen in isolation; as human beings, we are inclined to share and communicate our understanding of the world with each other. We can seek out and find new information to develop our understandings by asking questions of others. Educators can "...engage students by enabling them to contribute to the curriculum as well as to their community at large, and in the process, develop essential skills in problem solving, critical thinking, creative collaboration, and global communication" (November, 2012, p.5). The authentic work

students are engaged with in a classroom should be connected with the opportunity to communicate their new understandings and knowledge with others.

More specifically, setting aside a time during the day to meet as a classroom community to greet one another, share stories and focus on social skills provides students with the opportunity to exchange and clarify ideas in a structured setting that is complementary to their academic focus. "Learning how to listen, ask good questions, and examine situations from a number of perspectives is just as important in a child's development as academics (Gardner, 2012, p. 61-2). Classroom rituals and routines are important to setting the tone for the day and establishing a climate of trust and belonging in the elementary school classroom; the meeting time provides a space for students to practice the social skills of cooperation, assertion, responsibility, empathy and self-control. When sharing, students learn how to speak clearly with a strong voice, listen by taking turns, forming questions and seeing things from a different perspective (Gardner, 2012).

Effective communication is important to a STEAM learning model in the elementary school classroom because students need to be able to articulate their ideas and beliefs in a constructive way, as well as to be able to understand the ideas and beliefs of others that may contribute to their construction of knowledge. Learning is a social experience in which conversation has an important role in the construction of knowledge (Gardner, 2012).

Creativity. Creativity can be defined in many different ways, but considering its role in the elementary school classroom (and particularly in a STEAM learning model) students use a wide range of idea creation techniques in developing new ideas, demonstrate originality and inventiveness in their explorations, and see creativity as part of a long term, cyclical process (Partnership for 21st Century Skills, 2007). In order to be prepared for the challenges of society and the workforce, students need to leave school knowing how to create and innovate. In the world of global competition, innovation and creative spirit are fast becoming requirements for professional success (Partnership for 21st Century Skills, 2007). With regard to the connection between creativity and a STEAM learning model, it is important to note that "creativity is as important in education as literacy and we should treat it with the same status" (Robinson, 2011).

Through STEAM learning, students can experience an explorative state of mind as teachers work to cultivate curiosity in multiple disciplines (Gardner, 2011 in Rabalais, 2014). Creativity is a powerful part of learning because it contributes to enhancing student's ability to solve problems; also, the traits of creativity include "the application of original solutions to problems, collaboration, and dedication to future knowledge" (Welle-Strand and Tjeldvoll, 2003 in Rabalais, 2014). The study of arts integrated with science, technology, engineering and math encourages students to process information creatively--to invent, explore and imagine in ways that lead to detailed problem solving and greater social understanding (Rabalais, 2014).

Summary. It is necessary to reframe learning so that students see it not simply as a task to complete, but as an exercise in understanding the world around them and how they can play a part in the co-construction of new knowledge. Learning through a STEAM learning model should demonstrate to students that topics, as well as people, are interconnected and that what they know and do with that knowledge can have an impact far beyond themselves. A solid foundation in the 21st century skills of critical thinking, communication, collaboration and creativity are therefore essential to the successful implementation of a STEAM learning model in the elementary school classroom.

Digital Citizenship

Increased access to digital tools and resources means responsibly planning and implementing lessons that demonstrate for students what it looks like to use technology in an educational context (ISTE, 2007). Integrating digital tools and resources in a STEAM learning model has the potential to enhance student learning because it provides an engaging way for them to create, design and innovate. When it comes to preparing students for a world that demands more focus on engineering, science and math fields this goes hand in hand with being able to think creatively about solutions to social problems. Our society does much of this in the digital realm, and so providing students practice with this aspect of the work early on gives them a strong foundation for more complex work in the future.

Connecting back to student-led inquiry, there must be a focus on modeling for students what it looks like to use technology to research a topic. Though many of our students have grown up with access to digital devices,

> ...we can't assume that if students can read and write they can search the web. The web has its own very specific architecture of information that is quite different than the way we typically organize information on paper. The web also has its own grammar,

punctuation, and syntax, as well as its own rules for storing and retrieving information. (November, 2012, p. 50)

Students need to become familiar with how they can use the technology to which they have access in the pursuit of answers to their questions. One way that educators can support students in being responsible digital citizens as they research topics of interest is to reinforce the importance of not taking information and using it as their own.

Just as we do with reading and writing, if we are to truly educate our children to think critically on the web, we must train them to apply the same rigor and discipline to their online research that they apply to other skills across the curriculum. (November, 2012, p. 51)

In the context of the elementary school classroom, this means that students need to understand how and when to use information they find on the web, and how to find their own voice to say what they have learned.

Differentiation with digital tools. In thinking about how students are using digital tools within the collaborative groups to enhance their work, "the simplest way to document collaboration is to write it down. Digital recording tools provide a wealth of variations on this theme, making it easy for students to capture and store relevant moments" (Pahomov, 2014, p.65). Whether it is by taking notes in a shared Google doc or using a digital voice recording tool to record their conversation, students can be held accountable for the critical thinking piece that leads to more in depth work on a topic. Students could even use the camera on their device to take short video or photos of their work in progress to share with the learning community. Furthermore, "the emergence of easy-to-use creative tools can empower every student to become a contributor to the ecology of the classroom" (November, 2012, p. 27). Some students may tend to stay quiet because they are tentative to take a risk contributing during whole group conversations; digital tools give these, and all, students the power of having a voice and not necessarily having to speak publicly to share their understandings.

SAMR Model. Technology should be used to enhance student learning and allow teachers and students to modify and redefine their learning experience. The SAMR model outlines a progression of using technology to enhance student learning (ISTE, 2007). SAMR stands for Substitution, Augmentation, Modification, and Redefinition.

Simply adding technology--the thousand dollar pencil--to the current highly prescribed school culture won't help very much...successful implementation of technology into K-12 education is much more complex than providing students with access to computers and moving content to online courses. Instead, we have to teach students to use information and communication technologies to innovate, solve problems, create and be globally connected. (November, 2012, p.14)

Students and teachers alike need to move beyond simply substituting pencil and paper assignments with technology tools, and encourage students to be more than consumers of content. In a time when we can Google an answer to almost any question, students should be encouraged to design and innovate with digital tools rather than memorizing information. In the elementary school setting, this involves a focus on first building a foundation of basic skills and expectations around the use of technology in the classroom toward educational goals (ISTE, 2007).

Summary. To effectively prepare students for the rapidly changing world around them, educators must "...transform students from passive receptors of information into active drivers of their educational experiences and designers of their educational goals" (November, 2012, p. 20). Enhancing a STEAM learning model with developmentally appropriate digital tools and a focus on citizenship allows students to safely dig deeper into their questions, share ideas and design projects that demonstrate their understanding of a topic.

Learning Partnerships

A connection to parents, families, and the world beyond their classroom walls gives students a bigger reason to invest in the work that they are doing within the classroom. "Convincing parents and teachers that today's children need to understand these new, fundamentally different concepts may be the hardest work of all" (Martinez and Stager, 2013, p.56). In terms of making learning authentic, letting students know they have an audience will be a motivator for them investing in and making the most of the learning that they are doing; they can clearly see the connection between what they are doing in the classroom and the ripples that it makes into the community (Boss and Krauss, 2014).

Staff Development. It is often hard to think about breaking the mold and working outside of what is comfortable and familiar. For many educators, the idea of branching out and trying a new model for learning can be intimidating or stressful even if it is only for a portion of the academic day. "Unlearning is more difficult than learning something new, and one of our most important challenges is to let go of existing structures in order to build more effective ones" (November, 2012, p.15). There is certainly a learning curve, more planning required, and perhaps even the feeling of a loss of control as students develop their own learning paths and teachers begin to act more as coach and guide.

The best way to support teachers in making small changes to support a STEAM learning environment in the regular elementary classroom is to provide access to applicable professional development and time to plan collaboratively with others on their team. STEAM initiatives that are successful allow for collaborative planning time and professional development to support teachers in learning how to find and implement alignments between standards from two or more content areas with integrity (Riley, 2014). With purposeful planning, "...we have an opportunity to restore the dignity and integrity of a work ethic with redefining the role of the learner as a contributor to the learning culture" (November, 2012, p.6). The more that the learning can be shared and communicated through collaborative planning, the more students will have access to new ideas and perspectives in education. As educators we learn alongside our students; while we may be proficient at many things they have not yet mastered, they may also have insights and knowledge that we as adults can benefit from learning.

Parent Involvement. The way that many students' parents or grandparents experienced education is probably different in many noteworthy ways from a STEAM learning environment. "While life outside our schools has changed dramatically over the past century, we cling to an early industrialized classroom model that often fails to encourage collaboration, innovation, a global work ethic, or critical problem-solving skills" (November, 2012, p.5). For this reason, as well as the valuable component of nurturing a home-school connection, educators should communicate with families about the work that students are doing in a STEAM learning environment. Teachers can give students the opportunity to continue their projects at home as homework or parents and other family members could become involved with the work students are doing in the classroom by volunteering their time as a guest speaker on a topic or helping students with their projects during school hours.

Parent involvement is crucial to a child's attitude, understanding, and academic success in science education; "provide[ing] an event that inspires STEAM learning experiences for the entire family is a great way to engage parents and children together--something that the classroom alone cannot always provide" (NSTA 2009; Henderson and Mapp, 2002, in McCubbins, Thomas, Vetere, 2014, p.42). With this in mind, taking the step to involve community experts in informal science events is a key component to establishing a strong connection for students between what they are learning in school and what takes place daily beyond their classroom.

Community Experts. By inviting local universities, community organizations, businesses and nonprofits to participate in family science events, teachers can engage students and their families in the scientific and engineering practices outlined in the NGSS through an informal learning environment that emphasizes knowledge and skills rather than science content (McCubbins, Thomas, Vetere, 2014). During the event, students are encouraged to discover through hands-on activities and they can learn about careers in science from actual research scientists and science educators. Such an event is beneficial to students, parents and teachers: students can see a connection between what they learn in school and life outside the classroom, parents can see how to support their child's creativity and critical thinking, and teachers can gain resources and activities to use in their own classrooms (McCubbins, Thomas, Vetere, 2014).

A partnership with a local university or children's museum is a great way to access resources and opportunities for students and their families to engage with outside of the regular school day, and can provide a unique way to address a variety of standards that is engaging and innovative (McCubbins, Thomas, Vetere, 2014). This experience illustrates that the topics they engage with in school are also present in the everyday work of people in their community and not isolated to their classroom. Though it requires careful planning and many resources, a family science night can provide an important real world connection for students and their families.

Summary. Dedicated staff, parents, and community experts are all valuable pieces in establishing learning partnerships with students that will support them as they engage with authentic learning through the lens of a STEAM curriculum. Working as Professional Learning Communities (PLCs), teachers can intentionally align, plan for, and assess two or more standards associated with STEAM content areas; sharing learning experiences with families brings learning home. Partnering with informal community educators or experts in any of the STEAM fields of study builds authentic connections for students.

Conclusion

In my review of the literature, these themes emerge as integral to developing a successful STEAM learning model in the elementary school classroom:

- inquiry based learning

- 21st century skills
- digital citizenship
- learning partnerships

First, modeling for students how to ask questions that are not easily answered with an internet search provides them with the foundation for leading their own inquiries into topics that integrate math, science, and art in a meaningful way. As students work toward the learning goals for a given unit of study, teachers can guide and facilitate student learning and activate critical thinking by carefully planning and adapting questions that encourage students to reflect on their own thinking. This process of conferring and informal assessment supports student ownership of the learning.

Communication between all parties involved in student learning is key to establishing a successful STEAM learning environment because teachers, parents and community members all become active participants in the outcomes of student work; knowledge is not built in isolation, it is shared. Finally, technology can greatly enhance an elementary school STEAM learning environment. Teaching and reinforcing how to use digital tools and resources in responsible ways to ask and answer questions, create new things and share understandings is a crucial piece in developing responsible digital citizens.

In Chapter Three, I will address how each of these foundational elements can be used to develop a successful STEAM learning model in the elementary school classroom. My goal is to demonstrate that with flexible thinking and careful planning, educators can offer students the opportunity to take ownership of their own learning while challenging them to achieve relevant social and academic goals. I will discuss practical ways to integrate content that encourage students to ask their own questions, think critically about a topic, and apply what they learn creatively. I will highlight how digital citizenship and community partnerships can redefine student's experience of education and how the implementation of STEAM learning in the elementary school classroom encourages the 21st century skills of collaboration, communication, critical thinking and creativity.

CHAPTER THREE

Methods

Overview

In this capstone, I developed a practical set of resources and ideas for teachers of students in grades 1-5 to use in establishing a STEAM learning model in the classroom. I see STEAM not as a curriculum, but as an approach to integrating curricular areas that have different standards to be taught and assessed. An integrated curricular model provides a way in which specific standards can be aligned, taught and assessed together (Riley, 2014). My current experience is with third grade students, so I provided a sample unit of study modeling how inquiry, critical thinking, collaboration, communication, creativity, digital citizenship and learning partnerships can all be leveraged to foster an authentic STEAM learning experience for students.

I designed a practical guide for teachers who want to embed these foundational elements into their current practice with the goal of introducing STEAM units of study; examples are given of what the foundational elements might look like in a sample unit, and ultimately the goal is for my work to be versatile enough that individual teachers can take it and adapt it to fit a flexible curriculum that is socially relevant and responsive to student's strengths, needs and interests, as well as being focused in the standards that they teach. The question that anchors this work is: What are the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom?

The district in which I work has developed a STEAM learning model that is currently being used at the middle and high school levels. Over the course of the next few years, my vision is to have STEAM learning embedded within regular classroom time at the elementary school level so that students have an opportunity to see connections between various fields of study and do authentic learning across content areas that have mostly been taught in isolation. I would like this learning model to guide the foundational frameworks of classroom teachers who want to integrate science, art and technology into daily academics. This learning model can be adapted across the elementary school grades.

Philosophical Framework

My work is grounded in a constructivist, student centered learning philosophy. Jean Piaget advanced this theory of learning, which came to be known as constructivism; he argued that the learner constructs knowledge based on experience and that knowledge would not result from the learner simply receiving information without going through an internal process of sensemaking (Piaget, 1976 in Martinez and Stager, 2013). Piaget also advocated for interdisciplinary learning, which is at the heart of STEAM learning model. Nurturing interdisciplinary experiences, according to Piaget, would encourage the construction of meaning (Piaget, 1976 in Martinez and Stager, 2013).

This STEAM learning model also reflects the philosophy of John Dewey, who saw education as continuous growth throughout a lifetime as a result of personal motivation (Martinez and Stager, 2013). Dewey's focus on the important role of community and experience in shaping the educational process was reflected in his belief that students should be engaged in authentic interdisciplinary projects that were connected to the real world (Martinez and Stager, 2013); this, to me, is what a STEAM learning model in the elementary school can provide for students starting at a young age.

Finally, Seymour Papert's work in developing technology rich project based learning experience has bridged constructivism as a theory of learning to constructionism, a theory of teaching that implements constructivist learning (Martinez and Stager, 2013). His commitment to progressive ideals of education akin to those of Dewey and Piaget, specifically in the realm of using technology to enhance learning, guides my approach to establishing a foundation for STEAM learning in the elementary school that encourages students to ask questions, explore, create and solve problems with the use of digital tools and resources.

Theoretical Framework

I structured my STEAM learning model using the rationale of backward design and the six facets of understanding set forth by Grant Wiggins and Jay McTighe in *Understanding by Design.* The curriculum development model detailed in Understanding by Design (UbD) provides guidelines for how the desired understandings of a unit can be framed so that the outcome is transfer of learning to new settings or challenges rather than simply recall of information. (Wiggins and McTighe 2005) UbD frames the work from the perspective of the teacher, not the learner. Specifically, UbD focuses on unit planning rather than lesson planning, because a single lesson is too short an amount of time in which to develop big ideas, explore essential questions and use authentic application to transfer understanding. Once a unit is developed, individual lessons should flow naturally from the unit plan, allowing for more purposeful connection to the big idea. (Wiggins and McTighe, 2005)

I adapted the three stages of unit design described by Wiggins and McTighe in UbD as I developed my resources and sample unit of study. In order to show how the foundational elements of a STEAM learning model function within this framework, they have been woven throughout the design process:

- Stage 1: Desired results- This stage establishes goals or learning outcomes for the unit, develops the big ideas, essential questions and determines the knowledge that students will acquire by participating in the unit.
    - Planning STEAM units of study requires careful attention to which grade level standards will be used to frame learning objectives and to enhance student's learning experience through the curriculum that is being taught, allowing for in depth exploration of a big idea.
    - Develop essential questions connected to the big idea and find multiple ways for students to explore, discover and create based on the STEAM skills that they are using. (Riley, 2014)
- Stage 2: Assessment Evidence- This stage includes student's demonstration of understanding through authentic performance tasks and the criteria with which their work will be assessed; additionally, any other evidence of student achievement and self-assessment of learning.
    - Find developmentally appropriate ways in which technology can be utilized within a STEAM learning model that will

enhance student exploration, collaboration and creation as well as facilitating formative or summative assessment. (Boss and Krauss, 2014)

- Stage 3: Learning Plan- Here I have suggested learning experiences and instruction that will guide students on their path to understanding and achieving established goals (Wiggins and McTighe, 2005).
    - Use of an iterative design cycle supports the 21st century skills of critical thinking, collaboration, communication and creativity (Martinez and Stager, 2013); I explored the benefits of a design cycle within a STEAM learning model.

Audience

I designed this learning model to be flexible for students in grades one through five, however, my examples focus on content and performance standards for students in grade three. I teach at a suburban public school which is home to 634 students in grades one through five. Forty five percent of our students are eligible for free or reduced lunch, eleven percent receive EL services, and we are a relatively diverse school: fiftyeight percent of students are Caucasian, nineteen percent are Black, eleven percent are Hispanic, twelve percent are Asian and two percent are Native American. We are a Reward School, which means we are among the top fifteen percent of Title I schools in the state (Mounds View Schools, 2015). Regarding access to technology, students in grades three through five have 1:1 Chromebook use in their classrooms, and students in grades one and two have access to class sets of either tablets or laptops that can be checked out for use.

My immediate audience is the team of teachers with whom I teach third grade; I will use this learning model to develop STEAM units of study based on our third grade priority standards. More broadly, my hope is that this learning model can be used as professional development for teachers at other grade levels in the school to design meaningful integrated units of study based on their own grade level standards.

Procedures

My hope is that the development of this learning model will support teachers in integrating content learning within the regular elementary school classroom in such a way that students have more opportunity to transfer knowledge between areas of study and to do more extensive project based learning that involves problem solving through collaborative design and innovation. In using a design framework like UbD, teachers can adapt the content within the structure depending on the grade level and unit of study so that the foundational elements are present and the STEAM content is flexible. It is important that teachers have a structure to reliably use in designing challenging and authentic learning experiences encompassing the fields of science, engineering and art in ways that inspire students to see connections between reading, writing and math during their explorations and then transfer their understandings across their studies. My sample unit of study highlights essential questions to spur student discussion and investigation. Resources for inquiry, 21st century skills, digital citizenship and learning partnerships provide teachers with valuable ideas that can be used within any STEAM unit of study across grade levels.

Design. This STEAM learning model effectively sets the stage for a successful schoolwide classroom implementation in the future. Using the theoretical framework of backward design, I have built a resource that shows the potential for integrating the foundational elements of inquiry, digital citizenship, learning partnerships and the 21st century skills of critical thinking, communication, collaboration and creativity into teaching practice to support a successful STEAM learning model in any classroom; the unit of study is flexible depending on standards to be covered at each grade level, student interest, strengths or needs, and, of course, current events that bring social relevance to the learning that teachers plan. I mapped out a single unit of study for grade three, as this is my current area of focus; the design of my sample unit focuses on several grade level standards and demonstrates how the foundational elements for a STEAM learning model are integrated within the development of a big idea, essential questions, assessment, and student learning activities.

Within my sample unit, I focus on developing inquiry based learning skills, digital citizenship, modifying learning with digital tools, and connecting with families of students or community experts to expand the reach of student learning and fostering the elements of 21st century learning (critical thinking, communication, collaboration and creativity) which I see as woven throughout the other three themes; these are flexible and adaptable to any elementary STEAM unit.

Assessment. Another factor I considered in my design is how to assess student participation and performance during a unit of study; to this end, I provided examples of formative and summative assessment rubrics that can be tailored to a variety of different projects and learning targets, including both content and performance goals. Knowing that students will be working collaboratively, I created rubrics for teachers to use in assessing each student in the group individually as well as a team so that each student is held accountable for the learning.

Ethics

I did not collect data from students, as my primary goal was to design a resource that would support professional development toward the implementation of a classroom based STEAM learning model. Students were not surveyed during the course of my work, nor did I collect any student work samples to supplement this project. In creating this learning model, my hope was to provide context and direction for other teachers and staff that can be adopted and adapted in the development of their own STEAM units of study at our school.

Summary

I have created a resource for first through fifth grade and a sample unit of study for third grade adapted from Understanding by Design that teachers can use in the development of a successful STEAM learning model. This resource is focused around the foundational elements of inquiry, 21st century skills, digital citizenship and learning partnerships as instrumental in creating a strong and flexible student-centered STEAM learning model. I demonstrated how the structure of Understanding by Design can be adapted to plan STEAM units of study that give students the opportunity to experience learning in a way that inspires creativity and innovation while holding them accountable for deep understanding.

CHAPTER FOUR

Results

Overview

The purpose of this chapter is to propose a model for STEAM learning in the elementary school classroom anchored in the framework of Understanding by Design as well as providing a sample unit that address the question: How can teachers foster the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom? I will outline the steps that need to be followed and provide resources for designing a unit so that teachers can develop the foundational elements, as well as including a sample unit plan for third grade that demonstrates the use of the foundational elements within a STEAM learning model. The content of the framework can be adapted to reach students in multiple grade levels by addressing a range of themes depending on the focus of students' learning, while the foundational elements can be woven through that structure where appropriate. The focus will be on developing inquiry, critical thinking, collaboration, communication, creativity, and using digital tools and resources to demonstrate mastery of educational objectives; attention will also be given to ideas for partnering with families and community members to extend student learning beyond the classroom.

First, I will outline the stages of Understanding by Design which I used in the development of my STEAM learning model. I have modified the elements of Understanding by Design which I found most useful within the structure of my model. I will include practical ways that teachers in grades 1-5 can begin to shift their classroom instruction toward this STEAM learning model by nurturing the foundational elements of inquiry based learning, 21st century skills, learning partnerships and digital tools within that framework. Keep in mind, this resource is meant to be flexible.

Then, I will outline a sample unit plan for grade three to demonstrate that these foundational elements can be woven through STEAM learning with a specific goal in mind. Part of the relevance of a STEAM learning model within the current educational system is that it allows students to be flexible in their thinking, grow at their own rates and work in the ways that are meaningful and necessary to their development while also being pushed to think outside their schema by their peers, teachers and other adults that work alongside them to meet their goals. My intention is that this plan can and should be adapted to various units of study and used as a framework to support student inquiry and creativity rather than as a manual for how to teach STEAM lessons.

Foundations of Understanding by Design

In The Understanding by Design Handbook, Grant Wiggins and Jay McTighe (1999) detail six facets of understanding that are to be considered in all three stages of unit design: identifying desired results, determining acceptable evidence, and planning learning experiences and instruction. The Six Facets are summarized by stating the achievement that each type of understanding reflects. If we say that a student understands, then they can explain, interpret, apply, have perspective, empathize and have self-knowledge.

These facets of understanding are not to be used as a linear progression or fixed criteria for success, rather "...as a family of related abilities." (Wiggins and McTighe, 1999, p. 10-11) Furthermore, throughout the process of unit planning, be diligent in ensuring that student goals and objectives are detailed using verbs such as *support, justify, predict,* and *prove.* This provides students with clear action steps. This is covered in more detail when I discuss transforming understandings into performances and developing rubrics for performance tasks.

GRASPS (goal, role, audience, situation, product or performance, and standards for success, Wiggins and McTighe, 1999) is a framework useful in designing authentic performance tasks. A performance task is authentic if it helps students learn how adults use the same knowledge and skills they are learning in school in the world around them. It must also include the means by which students will be assessed for their understanding. As with the six facets of understanding, I will cover this in more detail when I discuss constructing a performance task.

WHERETO is a helpful framework for planning learning experiences and instruction. Pay careful attention to each question as you map out the details of learning and instruction for your unit, keeping in mind that this should be used as a tool for checking the elements of design and not as a prescribed formula for your design.

Table 1: WHERETO Framework

W	How will you help students know ***where*** they are headed and ***why***?
H	How will you ***hook*** students through engaging and thought provoking experiences that point toward big ideas, essential questions, and performance tasks?

E	What events (real or simulated) can students ***experience*** to make the ideas and issues real? What learning activities will help students ***explore*** the big ideas and essential questions? What instruction is needed to ***equip*** students for the final performance?
R	How will you cause students to ***reflect*** and ***rethink*** to dig deeper into the core ideas? How will you guide students in ***rehearsing***, ***revising***, and ***refining*** their work based on feedback and self-assessment?
E	How will students ***exhibit*** their understanding about their final performances and products? How will you guide them in self-***evaluation*** to identify the strengths and weaknesses in their work and set future goals?
T	How will you ***tailor*** learning to reflect individual ***talents***, interests, styles and needs?
O	How will you ***organize*** learning to ***optimize*** deep understanding as opposed to superficial coverage?

(Wiggins and McTighe, 2005, p.197-8)

Finally, as I explain the design process used in the creation of my sample unit, it is worthwhile to keep this in mind as you embark on your own unit design and subsequent teaching of the unit: "...curriculum design is an iterative, not a linear, step-by-step, standardized process" (Wiggins and McTighe, 1999, p.3) and "understanding is always a matter of degree, typically furthered by questions and lines of inquiry that arise from reflection, discussion, and use of ideas" (p.11). Remember to take into account your own creativity coupled with the needs and abilities of your students throughout the design process, and keep in mind that you will need to think flexibly and be willing to adapt the unit as you create it and as you teach it.

Desired Results

During the first stage of the design process outlined in Understanding by Design (Wiggins and McTighe, 2005), a teacher identifies the desired results of the unit of study. Within this stage of design, several important steps must be taken to develop an enduring understanding and essential questions that will guide the unit. An enduring understanding goes beyond discrete facts and skills to focus on larger concepts or processes and are transferrable to new experiences within or beyond the focus of the unit (Wiggins and McTighe, 1999). The enduring understanding is like an anchor for the unit; it refers to the big ideas that the teacher wants students to understand and gives the purpose to learning the content.

In this STEAM learning model, use the words big idea rather than enduring understandings to keep the language accessible to elementary school age students ranging from first to fifth grade. Ask the question: What do I want students to understand by the end of the unit? Taking time to be creative is a must. Look at the scope and sequence for your grade level as something with moveable parts. Rather than seeing separate areas of study, try to see cohesive ideas. For example, rather than teaching a geometry unit on angle measures, a separate unit on Ancient Egypt and yet another unit on synthesizing information from a text to demonstrate understanding, integrate them into a single STEAM unit about the architecture of famous landmarks like the Pyramids at Giza.

Establish Curricular Priorities. To arrive at a big idea, start by identifying the knowledge with which students should be familiar. What are the standards from various areas of study that will be part of the STEAM unit? Next, bring those choices into focus by specifying knowledge (facts, concepts, and principles) and skills (processes, strategies, and methods) that are important to student understanding. This middle step determines what is important for students to know and be able to do. Finally, determine what is worth understanding. Ask the question: *Why is this topic worth studying?* (Wiggins and McTighe, 1999).

In the creation of a STEAM learning model, it can feel like there is an overwhelming amount of important knowledge and skills to integrate because teachers are responsible for teaching across content areas. Start with a single ELA standard for the grade level and think about how to integrate science and art with the concepts students are expected to understand given the focus of that standard. Also, avoid the trap of feeling like it is necessary to include a standard from every STEAM discipline. For example, knowing that technology will be woven through a unit without making it an explicit focus, it is not necessary to include a specific technology standard in the design. Students will likely use math during their design work and will be developing solutions to problems much like engineers, but it may not always be necessary to include a specific math standard. In short, including only a few standards on which to focus is best because you can develop a more focused performance task and rubrics for assessment.

Identify a big idea. Take into account unit topics, content standards, and student goals and objectives. Filter these things through four lenses:

1. Enduring, big ideas that will have lasting value beyond the classroom
2. Big ideas and core processes at the heart of the discipline
3. Abstract, counterintuitive, and often misunderstood ideas
4. Big ideas embedded in facts, skill, and activities

(Wiggins and McTighe, 1999, p.83)

Potential big ideas do not have to fit *all* of the statements above, they are guidelines for focusing the unit on ideas that are worthy of understanding. Since a STEAM unit will have more than one content focus, make sure that they lend themselves to the same line of inquiry so that the resulting understanding is cohesive.

When brainstorming a big idea to use in a STEAM unit, make sure that students see connections to the world around them and develop some historical perspective in thinking about their own role in society. This STEAM learning model does focus on social studies as well as the other STEAM disciplines because it is essential to educating socially responsible citizens. To draw art and science into the mix, consider how students will use performance art, speech and debate in conjunction with scientific innovation to inform an audience about their understandings and design a solution to a problem using what they learn.

This process is nuanced, and therefore requires attention to variables such as scope and sequence, subject specific standards, student age and time. Furthermore, when integrating content areas within a STEAM learning model, the big ideas need to be applicable to each content area that is included. This might mean a separate big idea for each content area, or it could mean coming up with big ideas that pertain to all content areas included.

When developing the big idea, consider that topical understandings are specific to the unit topic, whereas overarching understandings are broader in scope. Use the language from topical understandings to develop overarching understandings. Then, focus the unit on a small number of big ideas that are transferable to other areas of study. (Wiggins and McTighe, 1999). A big idea is usually recognized as a theme, concept, ongoing debate or point of view, paradox, theory, underlying assumption, recurring question, or principle (Wiggins and McTighe, 2005). Use these guiding questions to help in identifying possible big ideas for the unit:

Table 2: Framing a Big Idea

Moving from Content Standards to a Big Idea ● Why do I want students to understand ________________________? ● What is the goal or purpose of understanding __________________? ● What specifically should students understand about _____________? ● What do experts understand about ________, and why is it important? ● If the unit on ______________ is a story, what's the moral of the story?

- What insights about __________________ should students take away?

(Adapted from Wiggins and McTighe, 1999)

Develop Essential Questions. Essential questions do not have one right answer. They are able to link to other important questions related to other subject areas and address the philosophical or conceptual foundations of the discipline. Essential questions should be framed in a way that inspires and keeps student interest. (Wiggins and McTighe, 1999) Frame the questions in student friendly language, and follow a "less is more" philosophy: a few essential questions per unit is best so that student work is clear and focused. Teaching from essential questions provides a model for students that their expectation is to question what they know and not just absorb knowledge. Here are some tips for using essential questions in a STEAM learning model for the elementary school classroom:

- Make sure assessment tasks are directly tied to the essential questions that guide the unit. The assessment should specify what pursuit of, and answers to, the questions might look like. Use student exemplars so students can clearly see what is expected of them.
- Do frequent informal check ins to make sure students understand and can find value in the essential questions.
- Post essential questions in the classroom and add to student notebooks. Making questions visible and accessible to students conveys their importance to daily learning.
- Connect essential questions to students background when possible- stories and examples that are familiar to them help them relate to the questions.

- Share essential questions with other grade level teachers so they have an awareness of what other grade levels are working on and what they might be able to connect to and build from the following year. This transparency allows for thoughtful vertical teaming.

(Adapted from Wiggins and McTighe, 1999)

Inquiry. Common school wide language for an inquiry cycle such as Wonder, Explore, Discover, Share should be implemented so that students have consistency in how to approach their inquiries from year to year. Teach it beginning in first grade, so that students have practice with the language and become familiar with the inquiry cycle. Making this a familiar routine provides consistency that saves time for teachers as students progress from grade to grade, giving them the ability to advance skills and understanding rather than starting from scratch with new language to describe the same inquiry cycle. Subsequently, teaching students how to develop their own inquiries related to essential questions encourages students to own their learning process and make it unique to their interests and abilities.

The importance of nurturing inquiry and developing a common school wide vocabulary for an inquiry cycle is important to guiding students toward becoming independent learners who think critically about the knowledge with which they are presented. Students need the opportunity to learn the inquiry cycle that will support them in asking questions and transferring understanding within an academic setting, and then be exposed to that same language for design learning consistently over the course of their time at the school; this will ensure that they will grow in their ability to take risks, create and innovate as learners. While the content students learn from year to year will change, being expected to approach learning as a questioner of knowledge will be consistent and they can grow more rapidly in their ability to think critically, be creative and communicate their understandings to others.

Acceptable Evidence

Within a STEAM learning model, students should be participating in learning experiences that help them to develop a deep and transferable understanding of a concept. A variety of evidence of student understanding can be used throughout the STEAM unit, as long as there is thoughtfulness in balancing students being able to use their knowledge in context and more traditional assessments such as quizzes, tests, and prompts. In this STEAM model, focus on formative assessments, developing performance tasks, and designing rubrics as ways to gather evidence of student understanding. The continuum of assessment suggested in the Understanding by Design approach to designing a unit of study is as follows: (1) informal checks for understanding, (2) observations and dialogues, (3) tests and quizzes, (4) academic prompts, and (5) performance tasks. (Wiggins and McTighe, 2005, p.152).

Formative assessment techniques. As a means of formative assessment in a STEAM learning model, use these techniques regularly during learning to informally check for understanding.

Table 3: Formative Assessment Techniques

Stop and Jot	On one side of an index card, students write what they

	understand. (Sentence Starter: Based on our study of ____________, I understand that ____________.) On the reverse side, students write what they don't understand. (Sentence Starter: Something about ____________ that I still have questions about is ____________.)
Exit Slip	At the end of a lesson or when they finish an assigned reading, students write a brief summary of their understanding of the key ideas presented. (For younger students or EL students who may struggle with this amount of writing, consider using digital tools to record oral responses). Sample 3-2-1 template: Three ideas I think are very important: • • • Two ideas I have questions about: •

	• One idea I want to learn more about: •
Question Jar	Identify a place where students can put questions at any time about concepts that they don't understand. This can be anonymous and is great for students who might not want to share in front of their classmates that they don't understand.
Concept Map (Web, flowchart, timeline)	Have students create a visual representation of a topic or process. This shows whether students understand the relationship among elements in a process or the connections between components of a topic.
Misconception Check	Present students with a common misconception about the concept, principle or process. Ask them if they agree or disagree and have them explain why. Can be posed as a discussion, written response, multiple choice or true/false quiz.

(Adapted from Wiggins and McTighe, 2005)

Transform understandings into performances. When considering specific ways that students can show their understanding, consider using the following performance verbs.

It is not enough to say that students will understand or learn something. There needs to be a specific action that can show what they are able to do with their understanding. Separating the actions by the six facets of design is helpful in a STEAM learning model so that there is a focus on a few specific facets and a balance across facets. For example, not all of the student understandings should fall under being able to explain; they should also be asked to take perspective and apply their knowledge. The "less is more" rule is important here too: keep a clear focus and don't try to include a performance related to all six facets.

Table 4: Performance Verbs

Explanation	Interpretation	Application
Demonstrate	Record	Adapt
Describe	Evaluate	Build
Design	Illustrate	Create
Express	Judge	Decide
Teach	Make sense of	Design
Justify	Make meaning of	Invent
Model	Make an inference	Perform
Predict	Represent	Produce
Prove	Tell the story of	Propose
Show	Translate	Solve
	Critique	Test

		Use
Perspective	Empathy	Self-Knowledge
Analyze Argue Compare Contrast Criticize Infer	Take on the role of Be like Be open to Believe Consider Imagine Relate Pretend that	Be aware of Realize Recognize Reflect Self-check

(Adapted from Wiggins and McTighe, 1999, p. 136)

To avoid the mistake of simply connecting a performance verb with a content standard:

- First, identify a targeted understanding and frame it as a generalization.
- Then, consider which facet of understanding would best reveal the targeted understanding.
- Finally, use the verbs associated with that facet to generate ideas for possible performance tasks. (Wiggins and McTighe, 1999)

Design performance task. The culminating performance task or tasks for a unit should be designed using GRASPS (goal, role, audience, situation, product or performance and standards for success) as an approach to making sure that the assessment is authentic and engaging. When using this framework within a STEAM learning model, consider what students will connect with most and create a story that hooks them into the learning. In designing a unit, remember that the elements of GRASPS can be developed depending on the student's needs, abilities and interests as well as teacher priorities in teaching. Perhaps the situation in a performance task will be developed first, and then deciding what role students would take in solving the problem next. Then, you might define the goal, audience, product and performance. These steps are not intended to be a set formula for developing a performance task; the complexity of GRASPS in STEAM planning will vary depending on the focus of the unit and age of students.

<u>Goal.</u> The goal should state an action students need to take *and* the reason for which they are taking the action. For example:

- Summarize the procedure for _________ to _______________.
- Explain the justification for ________ to __________.
- Teach ________ about ________.
- Design ________to teach _______ about __________.
- Create a ________ to ___________.
- Persuade ________ to ___________.
- Defend _______with __________.

(Adapted from Wiggins and McTighe, 1999)

<u>Role.</u> Next, clarify the role a student will take on as they work through the performance task. This helps students see the connection between the work they are

doing and what experts in the real world might do with the same content. Here are some possible student roles that can be used in designing a performance assessment:

Table 5: Performance Task Student Roles

advertiser	artist/illustrator	author
biographer	elected official	coach
detective/eyewitness	editor	engineer
filmmaker	historian	inventor
interviewer/reporter	playwright	product designer
scientist	tour guide	teacher
researcher	expert in _________	museum director
photographer	lawyer	travel agent

(Adapted from Wiggins and McTighe, 1999)

Audience. Students need to have a target audience for their performance task so that they understand the value of their work to people other than themselves and their teacher. This is also a great time in the planning process to think about whether you can connect students with the school community, parents or outside experts who can listen to them present their work and ask them questions about their understandings. Here are some possible audiences (real and imagined) for performance tasks:

Table 6: Performance Task Audience

board members	boss	celebrities
community members	friends/relatives	advertisers
businesses	customers	experts
judge/jury	museum visitors	neighbors
newspaper readers	school staff	older/younger students
visitors/travelers	historical figures	government officials

(Adapted from Wiggins and McTighe, 1999)

Situation. When you develop the situation for the performance task, think about the context the student will find themselves in given their goal, role and audience and tell the story of what students will need to be able to do and why. Elaborate on the goal of the performance in more detail; this is a great place to tell the story that is behind the learning in which they will be engaged. Students really embrace the idea of having, or being on, an important mission- especially when it is presented within a story in which they get to play protagonist.

Product and performance. Finally, decide on the product or performance that will provide you with evidence of student understanding so that they know from the beginning what they are working toward. Be clear about what students are expected to do and frame that expectation with an explicit purpose, goal and audience. Also, be sure to identify standards for success that their product or performance must meet. Here are some possibilities for products and performance:

Table 7: Performance Task Products and Performance

Written	Oral	Visual
biography	debate	advertisement
book review	discussion	cartoon
brochure	interview	photocollage
questionnaire	play	diorama/display
newspaper article	song	slide show
script	speech	film/video
essay	teach a lesson	drawing

(Adapted from Wiggins and McTighe, 1999)

Present your performance task by telling an engaging and straightforward story. Even if storytelling is not your preferred mode of conveying information, trust that a really great story set up for a performance task will hook students from the beginning of the unit, and keep them motivated throughout their learning. Use this as a simple check as you think about how to frame a story using GRASPS:

"Students, your goal is to _______________. You have been asked to ___________. Your audience is _______________. The situation is ____________. You will create a ________ to _____________. Your finished work needs to ________________."

(Adapted from Wiggins and McTighe, 1999)

Developing Rubrics. In this crucial part of unit design, focus on assessment of both content and performance using the six traits of understanding as a structure for developing rubrics. The focus, then, is not only on the acquisition of content knowledge but also the student's ability to develop the skills of a 21st century learner: succinctly, that they can collaborate, communicate, share and transfer content knowledge into their daily lives. A rubric for content and performance requires that students must demonstrate both that they have reached an understanding of the content and have demonstrated skills necessary to the development of a performance task.

Rubrics are a useful means of assessing student progress toward STEAM learning goals for both students and teachers.

Rubrics provide teachers with specific criteria for assessing student understanding, a tool for increasing the consistency of evaluation among teachers, and clear targets for instruction. Rubrics provide students with clear performance targets, expectations about what is most important and criteria for evaluating and improving their own work. (Wiggins and McTighe, 1999, p.162)

Ultimately, the criteria used in the rubric should communicate the important qualities of a student's product or performance. These performance criteria should be adopted school wide so that students are familiar with expectations from year to year and are not surprised with a new language and structure for assessing their progress.

Table 8: Performance Criteria for Scoring Rubrics

Effective	Purposeful	Accurate
Clear	Efficient	Precise
Coherent	Persistent	Skilled
Graceful	Critical	Proficient
Well Crafted	Thoughtful	Focused
Well Presented	Careful	Insightful
Organized	Responsive	Fluent
Thorough	Polished	

(Adapted from Wiggins and McTighe, 2005)

Below is an adapted framework (Wiggins and McTighe, 1999) organized around the six facets to inform the development of rubrics for a STEAM unit. The range of progress is simplified to beginning (1), developing (2) and secure (3). For each of these levels of student achievement, there is a descriptor included that can be used to frame comments on student progress toward the goal(s) of the STEAM unit of study. To adapt this to any STEAM unit of study in the elementary school classroom, use only the facets of understanding that are applicable to the goal(s) of the unit. See Appendix C for further examples of what this can look like.

Table 9: Rubric Frame Using the Six Facets of Understanding

	Explanation	Interpretation	Application
3: Secure	Sophisticated	Meaningful	Masterful
2: Developing	Developed	Perceptive	Able
1: Beginning	Naive	Literal	Novice

	Perspective	Empathy	Self-Knowledge
3: Secure	Insightful	Mature	Wise
2: Developing	Considered	Aware	Thoughtful
1: Beginning	Uncritical	Egocentric	Innocent

Anchor Unit Design. Finally, take the time to refine and revise a rubric depending on the levels of student work that emerge. A rubric becomes more specific by carefully analyzing student work samples which is important because it gives more clarity to students and teachers as they connect the abstract language of the rubric to actual examples. (Wiggins and McTighe, 1999) Develop student exemplars for self evaluation and peer review so that students have a clear vision of how their work is being evaluated and what they need to work toward. For the purposes of a STEAM learning model in the elementary school classroom, a simple range of beginning, developing, and secure is sufficient to give students a clear sense of their progress in relation to content and performance standards for success. These markers for student success can be used in conjunction with the six facets of understanding and the abovementioned performance criteria. See the sample third grade unit plan for an example of what a rubric combining these structures looks like.

Learning Experiences and Instruction

In order for the STEAM learning model to be successful, the learning experiences planned must be both engaging and effective in helping students understanding achieve the desired understanding. Be thoughtful about making sure that the projects students are asked to participate in during their learning are both "hands on" and "minds on" activities. Furthermore, consider how you can work to uncover student understanding of a concept by taking into account possible misconceptions that the student might have as the work through the learning. Another important consideration to keep in mind is that a STEAM learning model is not designed to cover content quickly, it is designed to allow students to uncover deep understandings and see connections between areas of understanding which will strengthen their ability to transfer their knowledge when faced with new skills and tasks.

WHERETO. Earlier, I summarized the importance of using WHERETO to frame student learning experiences and instruction within the design of a STEAM unit. Below, I have reiterated guiding questions for WHERETO, as well as providing ways to enact each element. Remember to adapt the suggestions to meet the specific needs of your students depending on age, ability and interest.

Table 10: Planning a Unit Using WHERETO

How will you help students know ***where*** they are headed and ***why***?	Make sure students know what their assignments will be, what their performance task is, and the criteria by which their work will be assessed. ● Post essential questions where students can see them daily ● Go over rubric and student exemplars ● Create student copies of requirements, deadlines, checklists, rubrics and references that they can refer back to in the classroom ● Connect to family by updating grade level website with essential questions, project deadlines, requirements and references so students can be supported in their work at home.
How will you ***hook*** students	Bring up an interesting fact, issue or

through engaging and thought provoking experiences that point toward big ideas, essential questions, and performance tasks?	problem that students can relate to and that raise essential questions. • Begin a unit with a mystery that needs to be solved • Challenge students to react to a statement that evokes strong opinions • Pose an interesting question that others have had when studying the content
What events (real or simulated) can students ***experience*** to make the ideas and issues real? What learning activities will help students ***explore*** the big ideas and essential questions? What instruction is needed to ***equip*** students for the final performance?	Use digital resources to redefine student experience of the ideas and issues they are studying. • Explore ideas and questions by searching the internet using Kiddle or other kid-friendly search engines • Develop survey questions or interview an expert via Skype about the content in question • Model, model, model how to use digital citizenship when gathering information or conversing online

	(develop age appropriate norms and guidelines for searching the internet) ● Coach students in communication etiquette to prepare them for digital interviews with community experts and presenting their performance or final product to another classroom, teacher or parent volunteer
How will you cause students to ***reflect*** and ***rethink*** to dig deeper into the core ideas? How will you guide students in ***rehearsing***, ***revising***, and ***refining*** their work based on feedback and self-assessment?	Question students throughout the unit to help them reflect and dig deeper into core ideas as well as uncovering misconceptions and misunderstandings. ● Encourage students whenever possible to ask their own questions connected to the big idea. Make sure they become comfortable with the feeling of posing a question that might not have a direct answer. ● Post student exemplars for beginning, developing and secure student performance alongside rubric

	for performance criteria. ● Students practice teaching what they know to another classmate or family member so they can comfortably express their understanding of the content. ● Guide them back to the inquiry cycle (ask, imagine, plan, create, improve) to help them refine their work.
How will students ***exhibit*** their understanding about their final performances and products? How will you guide them in self-***evaluation*** to identify the strengths and weaknesses in their work and set future goals?	Make time for students to share their work with a real audience (physical or virtual) ● Perform/present final projects for another grade level or visiting parents ● Students can network with learning communities working on the same project around the world (The Center for Innovation in Engineering and Science Education (CEISE) is a great resource for instructional

	materials to support this goal.) www.k12science.org ● Collaborative groups and individuals self assess their products and performance (see appendix for sample rubrics for individual and collaborative group work)
How will you ***tailor*** learning to reflect individual ***talents***, interests, styles and needs?	Ideally, this individualization in learning happens flexibly depending on student need. Adjusting the route to the intended goal is simply good teaching. Refer to GRASPS and consider the product or performance that students are completing, and then decide what can be adjusted or adapted to meet students where they are at in their learning. Be clear about where you want them to arrive with their understanding, and willing to provide various routes to reaching that point. ● Give the option of using written, oral or visual means of fulfilling the learning objectives for the

	unit. ● Plan collaborative groups pairing students with different strengths together (refer to collaborative group roles)
How will you ***organize*** learning to ***optimize*** deep understanding as opposed to superficial coverage?	Plan carefully and comprehensively before beginning a STEAM unit. Make sure big ideas and essential questions are well defined, assessments are in place, and you have a clear grasp of what students will need to do in order to successfully show their understanding of the content. ● Be willing to adjust and adapt the unit as necessary depending on student need, ability and interest. ● Connect each learning activity back to the big idea ● Connect student work to work done by experts outside of the classroom ● Provide clear objectives and

	criteria for success ● Draw connections between the areas of focus throughout the unit, scaffolding students to be able to articulate how science, art, math and other disciplines are related.

(Adapted from Wiggins and McTighe, 1999)

Questions to uncover understanding. During observations and dialogues with students, ask them questions that require them to explain, interpret and apply their understanding. Use questioning as a formative assessment during initial inquires, group discussions, and work on performance tasks. Give students the option of responding to questions orally or in written form on an exit ticket. Here are some examples of questions that will uncover student understanding based on the six facets:

Table 11: Using Questioning to Uncover Student Understanding

Explanation	Perspective
How is _______ connected to _______? What are the characteristics/parts of ___________________________________? What is the big idea in __________?	What are different points of view about__________________________? How is ________similar to/different from _______________________________? What is the evidence for __________?

What are examples of __________?	
Interpretation	Empathy
What is the meaning of ____________? How is ______ like ______________? How does ____________ relate to me? So what? Why does it matter?	How would _______ feel about _______? What was ______ trying to make us feel? What would it be like to walk in _______'s shoes?
Application	Self-Knowledge
How can _______help us to _________? How and when can we use this knowledge/process? How is _______ used in the world around us?	How do I know that ____________? How can I show that ____________? How is my opinion about _________ shaped by ___________? What are the limits of my knowledge about __________?

(Adapted from Wiggins and McTighe, 1999, p. 220)

Table 12: Follow Up Questions

Why?	How do you know?	Explain.
Do you agree?	What do you mean by	Tell me more.

	______?	
Give your reasons.	Could you give an example?	What about ________?

(Wiggins and McTighe, 2005, p. 249)

Memorize these simple follow up questions, tape them to a clipboard, have them with you as you check in with students during their work. Use them liberally to challenge students' critical thinking. These questions encourage students to communicate their understandings and allow you to uncover their misunderstandings or misconceptions that would otherwise be invisible. When integrating content areas in a STEAM learning model for the elementary school classroom, these questions serve to uncover student's progress toward understanding how the concepts are related and how they are applied in real world problems and situations.

Tell a Story. Give a narrative structure to the STEAM unit by becoming a compelling storyteller as you present necessary information to your students. This will raise the level of interest in the learning and spark student motivation. Additionally, use this mode of presenting information to students as inspiration for them to take the reins and become storytellers of their own understandings. Students can use this creative structure in the development of their own performance tasks. Rather than simply consuming and remembering information, students have the opportunity to produce art: suddenly, the topic they are studying has weight, personality, and emotion beyond the words on a page or instructions given them by somebody else.

Table 13: Storytelling Elements for Teachers and Students

Setting	Where and when does the story take place?
Characters	Who are the major and minor characters?
Opening	How will students be drawn into the story? (e.g., reader, viewer or listener)?
Obstacles/Problems	What problems must be solved? What obstacle needs to be overcome?
Dramatic Tension	What opposing forces are at work (e.g., ideas or characters)?
Surprises and Twists	What surprises, ironies, twists, and unexpected turns will be built in?
Resolution or Solution	How are obstacles overcome? How is the problem solved? How does the story end? What might the sequel be?

(Wiggins and McTighe,1999, p. 231)

<u>21st century skills.</u> Develop and model norms for academic conversation and respectful discussion within large or small group settings. Students in elementary school need to be able to discuss their thoughts and ideas in order to develop and advance their knowledge and understanding of academic content. These discussions can be adjusted to

suit student readiness (they will become more advanced just as standards become more advanced as students progress through the grades). Nevertheless, students should have plenty of opportunity to practice spoken communication and those practices should be rooted in a common school wide language to support student growth and success from grade to grade. These are the discussion norms, sentence starters and group roles that I propose using within a STEAM learning model.

Table 14: Discussion Norms

We always respect each others ideas.
We invite someone to contribute by asking them a question.
We give proof of listening (nod your head, look at the speaker, wait turns to talk).
We clarify, challenge, summarize and build on each others ideas.
We stick to the discussion point.

Table 15: Sentence Starters for Expressing Ideas and Building Conversations

Validate/Assert I think that… I agree because…	Challenge I disagree because…
Question I wonder if…	Summarize I heard you say that...

My question is...	
Elaborate Building on… Bridging to… Linking to…	Clarify What do you think… Why do you think… What did you mean when you said...

Group work roles and tasks purposefully align with the cooperative group work rubric that I have included in Appendix C. In this way, I can hold students accountable for being responsible for any of the four aspects involved with keeping the group on track. Students, depending on the unit, may be responsible for completing individual performance tasks; nevertheless, cooperative group work in other learning experiences leading up to the final product or performance are excellent for practice in collaboration and communication. Additionally, there should be an element included in each cooperative role that requires continual participation from all students so that they are not inclined to check out when they feel their task is complete.

Table 16: Cooperative Group Work Roles and Responsibilities

Role	Task
Task Manager	Keeps the group focused on the discussion topic/project and is the "point person" for the group
Time Keeper	Manages the time the group has to discuss/ work on the

	project, tracks progress toward end goal.
Spokesperson	Shares a summary of the discussion/project with the whole group, accountable for inviting all group members to participate during work time.
Recorder	Keeps notes during work/conversation on the ideas shared by the group, writes a summary of the discussion/progress made on project.

Digital Tools

The use of technology within a STEAM learning model should help students stay organized, focus on their learning goal, and connect with the community. With these points in mind, teachers can carefully plan and consider how implementing the use of digital tools by students during their learning can impact their creativity and ability to innovate within a STEAM learning model. Refer to ISTE for technology standards and more on the SAMR model for technology integration (for these and other resources to consult in the design process, see Appendix E); educators have the responsibility to make sure that we are not just replacing paper and pencil work with computers. We need to strive toward reimagining how technology can transform learning. For example, in a STEAM learning model, students should have the opportunity to interact with people across the city, state, country or world about their learning. Collaborative network science projects, such as CIESE'S The Square of Life Project (Square of Life, n.d.), can redefine student's use of technology as they develop understandings in science, math and engineering.

Connecting back to designing a performance task for students, embark on a STEAM unit with the following question in mind: Who is the audience for this work? Will my students be sharing their understandings with their families, our school, or the larger community (either local or global)? Students can utilize digital tools and resources to connect with the community to develop their knowledge and share their learning. For example, students can design a website which they can use to tell the story of their work on projects and presentations over the course of the year. Work like this redefines technology because it requires students to be thoughtful about the structure, design and coherence of their work. As this is challenging work for many third graders, first and second grade teachers can consider creating a class website to house the story of their class's work as a whole.

The following are some examples of digital tools that allow students to work creatively within a STEAM learning model to gather, demonstrate and share their knowledge. Keeping in mind that students are working at various levels of understanding, the responsible use of such tools naturally allow students to adapt the learning to their individual progress. Model for students responsible use of these tools and explore the ways they can be used; once students have learned to use them responsibly, connect the use of these tools to clearly defined learning activities and performance tasks.

Table 17: Digital Tools for Student Learning, Engagement and Assessment

Digital tools	Ideas for use
Vocaroo	● record a family member telling a story
Clipchamp	● make a how to video, document the process of creating a model, act out and record a skit
Kidblog or Flipgrid	● Students reflect on their learning process through writing or video
Storybird	● Write and publish creative writing
Scratch	● Coding
Quizlet or Quizziz	● Review important academic vocabulary and information associated with a unit of study ● Teach students to create and administer their own quizzes based on their own learning.
Google Suite ● Sites ● Forms	 ● students construct a site where they can document their work over the course of the school year ● students write questionnaires for surveying

	classmates, teachers or parents about a topic
● Slides	● students can present information with the added capability of linking websites, videos or audio.
● Docs	● students can take notes on a topic, and easily share information with group members
● Hangouts	● students have the opportunity to converse with community experts on a topic or other classrooms to share ideas and ask questions in real time

Finally, make sure that parents are informed about the use of specific digital tools in the classroom before their students use them, especially if it requires a parent's approval; however, many web based apps and learning websites are vetted for elementary school aged children. Send home a letter when introducing new digital tools that will be used in the classroom in conjunction with defined unit goals and objectives. Explain how the tools can benefit students' learning experiences in the classroom and connect them with a community of learners and experts in the world around them.

Learning Partnerships

Build opportunities for students to see their learning as transferable to the world around them by taking the time to connect with parents, professionals, organizations and digital networks. Using digital tools to connect with community partners helps develop digital citizenship when asking questions, communicating and sharing knowledge.

These experiences with other people can support, enhance and redefine a student's experience of the learning that takes place in a STEAM learning model.

Community partners. Using a field trip to launch or wrap up a STEAM unit of study is a great way for students to transfer their understandings between content areas. There may be volunteers or staff whom students can interview about their questions or who may be willing to visit the classroom to assess student performance tasks. Community partners provide valuable expertise in how to integrate art, science and engineering into learning and also in showing students that the topics they are learning about at school have application in everyday life outside of school as well. See Appendix D for a list of potential partners in learning and their available programs and resources. While this list is not exhaustive, they are directly related to science, technology, engineering, art and history.

If field trips and school outreach programs are too expensive or time consuming within the constraints of a busy school calendar, a great way to connect students with new voices and ideas is through digital communication like Skype or Google Hangouts. Students can communicate with community experts in the fields of science, technology and engineering to learn more about their area of expertise and how it pertains to what students are learning in the classroom.

Whether it is a field trip or Google Hangout with a research scientist, partnering with people and places around the community builds in students the valuable understanding that learning has few boundaries, and shared understandings build new knowledge. Use of digital tools and resources with clear goals and objectives focused on the performance task and other assessments can redefine student learning in a STEAM learning model.

Parent Partnerships. Keeping families updated about the learning that is taking place in the classroom provides students an important way to reinforce and transfer their learning. Teachers can be communicating out a week in review, month-at-a-glance for upcoming learning goals, periodically sharing student work in progress and asking families to reinforce learning at home by sending home discussion topics or writing prompts. Students can even share responsibility for creating newsletters or updating classroom websites to reflect current STEAM units of study, learning goals and activities. Another creative way to share learning with families is through the use of a classroom digital scrapbook (utilize google slides, share with families, and update regularly) or social media posts. Include photos of students during their work, student statements about their work or even a script of class discussion around the topics that are the focus of their work).

Involving families with the learning that is taking place in the classroom is a valuable way to show students that their education transfers to all parts of their life. Have students interview their families about their own experiences with school. Students can write a narrative essay about a family member's experience with education or why they chose the career they chose. Also, students may have parents, grandparents or other family members who work in roles throughout the community that connect directly to the content being studied. Invite them into the classroom to share their knowledge with the class or share in the work that students are doing.

Third Grade STEAM Unit of Study

Bringing together the theoretical framework of Understanding by Design and the foundational elements of a STEAM learning model which I propose throughout this project, I have written a unit of study for third grade (see Appendix A). This shows what it looks like to pull several standards from the scope and sequence of study for a grade level and combine them into a single unit. Added to relevant stages in the Understanding by Design planning process are ideas for use of digital tools and community partnerships (inquiry based thinking and 21st century skills naturally fall into all three stages of the planning process without being highlighted separately). Appendix B contains a template which can be used to guide the design of a STEAM unit of study.

Conclusion

In the development of this resource, my goal was to merge practical unit planning adapted from Understanding by Design with resources that address the foundational elements of a STEAM learning model as they would apply to each step of the planning process. With careful planning of desired results using big ideas and essential questions; acceptable evidence, including performance tasks and assessment rubrics; and clearly focused learning experiences and instruction incorporating digital tools and community partnerships, teachers can integrate content in a STEAM learning model that would otherwise be taught in isolation. Careful attention must be given at the beginning of the design process to which standards from various STEAM related content areas will be the focus within each unit. Having these foundational elements in place will allow for the successful implementation of a STEAM learning model in the elementary school classroom.

CHAPTER FIVE

Conclusions

Overview

I began this project with more questions than I had answers, and more ideas than I had time to pursue. After some exploration, I landed at the question that felt most connected to my day to day experience in teaching and also my desire for student learning to have greater depth and transferability: What are the foundational elements necessary to the successful implementation of a STEAM learning model in the elementary school classroom? Ultimately, I identified four elements as foundational: inquiry; the 21st century skills of collaboration, communication, creativity and critical thinking; learning partnerships; and digital citizenship. Setting out to create a STEAM learning model with these things as the foundation, I truthfully didn't know where I would find myself in the end. My hope was always that I could create something that would benefit both teachers and students in a way that created balance, structure and innovation in learning while minimizing the stress and guesswork that comes along with trying something new or different from our daily practice. Weaving together many elements to create such a model felt like a monumental task, one that at times I wasn't sure I had the mastery or the wherewithal to accomplish--but I always had the desire to see it through.

Ultimately, the successful implementation of a STEAM learning model in the elementary school classroom gives teachers the ability to connect the subjects they teach in a meaningful way so that students gain new understandings. The path to developing comprehensive and thoughtful units of study for each grade level certainly does require additional time and energy, but there is a positive outcome for both teachers and students that we, as educators, cannot afford to ignore. Our world is changing rapidly, and the perspectives and possibilities that come to us in each student deserve to be met with something different than what we've always done. Change can be hard, but there is so much value in making sure that students have a flexible, challenging and innovative experience at school so that they can be better prepared for success beyond school.

Reviewing the Literature: In Retrospect

Through the process of reviewing the literature on STEAM and the foundational elements I proposed, I refined my ideas about how the many facets of such a learning model fit together, beginning with an understanding of the philosophy behind STEAM learning. The literature led me to consider integrating content and the importance of art in that process as a means for developing skills in subjective thinking, observation and communication. The Next Generation Science Standards (NGSS Lead States, 2013) also helped guide my identification of foundational elements for a STEAM learning model due to the focus on asking questions, problem solving and critical thinking.

The parts of the literature review that proved to be most important for my capstone were those that explored inquiry and 21st century skills because they were most connected with the theoretical framework which I used in my unit design. I incorporated inquiry as a means for identifying desired results, a way to informally assess students during the learning process, and as a practice for students to engage in throughout their learning process. I incorporated collaboration, critical thinking and communication in most of my learning experiences and instruction as they provide students with important practice in sharing ideas, articulating perspectives and respectfully questioning different points of view.

An important juncture for me in this process was in taking the foundational elements I had identified for a STEAM learning model and determining how they fit into the established theoretical framework of Understanding by Design. The literature I reviewed refined my vision for student learning, and the framework of Understanding by Design complemented the foundational elements I identified as important to developing a successful STEAM learning model in the elementary school classroom. I have a new understanding of how much time and effort goes into the complex process of designing a STEAM unit of study after poring through the literature.

The literature review provided me with the background and framework I needed to feel familiar with the history of STEAM learning and how it can benefit student understanding; I was able to use these understandings along with the theoretical framework of Understanding by Design to model what would go into developing a unit of study based on the foundational elements of a STEAM learning model. The literature supports that inquiry based learning, digital citizenship, learning partnerships and 21st century skills go hand in hand with the intent of developing a STEAM learning model: that students are able to experience their learning as relevant, enriching, interesting and connected to their everyday lives.

Implications and Limitations

I understand that the reality of this learning model being implemented on a large scale is easier said than done. I will refine this work so it is easier to implement, more comprehensive and suited to the needs of individual grade level teams of teachers. In the world of teaching, there will always be the limitation of time and the overwhelming need to “cover content”. While this model shows it is possible to “uncover” necessary content through the design of STEAM units of study, there is still a lot of creative work time that needs to be invested in the alignment of standards, framing of essential questions and creation of common performance assessments and rubrics for student understanding. Reimagining a scope and sequence for learning over the course of an entire year and grade level with established math and literacy curriculum in mind while weaving in engineering, art, technology and science is no small task. Putting it all into a unit plan that shows what students should be able to do as a result of the learning takes drive, dedication and the desire to do things differently as a professional and for students.

Rather than framing the abovementioned tasks as limitations, there needs to be conversation around how to develop systems for the creation of these common units of study at each grade level. Grade level leadership should convene to determine a timeline or goals around implementation, and monthly staff development around aligning standards for a STEAM unit of study or using big ideas and essential questions to frame student learning targets will support teams in successful implementation. Another implication of this learning model is that teachers and students have the benefit of sharing a common language for inquiry, collaboration and communication so that as students pass from grade to grade they are able to build upon prior understandings.

I know that developing STEAM units is not easy or fast work. It requires extra effort and the dedication of many people to make it successful. That said, I think there is a lot of potential pay off for teachers and students in developing a STEAM learning model for the elementary school grades because it allows content that would otherwise be taught in isolation to be integrated and assessed through authentic performance tasks, giving students the opportunity to connect their understandings developed in the classroom with how those understandings are applied in the world around us.

Future Work

Moving forward, I see my future work as the implementation of a STEAM learning model in my third grade classroom that highlights performance tasks as a means for assessing student understanding. I will work through the process of adapting rubrics and learning experiences based on student performance. I will also experiment with network science projects and other means of connecting students with other learners and experts in the community. I would like to share my learning from these experiences with teams of teachers, providing professional development and coaching around developing big ideas and essential questions, creating authentic performance tasks and rubrics for assessment, and planning learning experiences and instruction for a STEAM unit of study; specifically, the development of a school wide language for performance criteria, inquiry cycle and discussion norms as crucial to building a foundation that students can carry with them from grade to grade.

Recommendations

Based on the work I have done, I would recommend that teachers collaborate closely as grade level teams to align standards for a STEAM learning model from their scope and sequence. This is a crucial step to identifying desired results and ensuring that students have a clear focus for their learning as well as having access to the grade level standards which they are expected to master in reading, math, art, science, and social studies.

Secondly, create authentic performance tasks and clear rubrics for assessing student's understanding and performance that identify specific performance criteria and clear targets for instruction. Having a clearly defined performance task will give students the opportunity to transfer their knowledge of STEAM related concepts and skills to a real world situation which is essential to the success of this learning model. Having a clear sense of desired results will support both teachers and students in the work of attaining transferable understanding related to the big ideas and essential questions of the STEAM unit.

Finally, make sure that the design of learning experiences and instruction allows students to develop the 21st century skills of communication, collaboration, critical thinking and creativity within the context of work that is socially relevant. Take the time to craft a narrative that will engage students in the big idea and encourage them to work to find answers to the questions and feel confident in asking more questions.

Conclusion

In exploring the foundational elements of a STEAM learning model and how best to integrate them at the elementary school level, perhaps the most important thing I have learned is that nothing in this process is fixed or formulaic. There is a necessity to becoming comfortable with the unknown, and taking a calculated risk in trying something unfamiliar rather than sticking to the old, worn path. The word innovation comes to mind when I think about the process of designing a STEAM learning model. There seems to be such a benefit to teachers approaching their work as they expect students to approach their learning: in integrating content with the desired result of authentic, complex and transferable understanding.

One of my many goals when I walk into my classroom is that the student's experience of learning be both seamless and dynamic; seamless, in the sense that they are able to move from one aspect of learning to the next without feeling like they have to shift their focus entirely from topic to topic (content area to content area), and dynamic in the sense that what they are studying can be flexed to fit their individual strengths, needs and interests. Using the foundational elements as discussed in this project, students are afforded the opportunity to develop lifelong skills and understandings that they will be able to transfer and utilise in any academic course of study as they progress in their education.

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APPENDIX A: THIRD GRADE STEAM UNIT PLAN

Appendix A: Third Grade STEAM Unit Plan

Unit Title: Everyday Innovation: Can Science Change the World?

Subject/Topic Areas: Science, Literacy, Social Studies, Art

Key Words: invent, innovate, society, science, technology, time, change, progress, solution, problem, design, responsibility, advantage, disadvantage, cause, effect

Designed by: Ariel Starzinski

School District: Mounds View Public Schools

School: Valentine Hills Elementary School

Grade Level: 3

Time frame: 3 weeks

Summary of Unit (Curricular Context and Unit Goals)

- In this unit, students will explain how scientists, inventions and innovations have changed society over time and can continue to have an effect on society into the future.
- In the culminating performance task students will work in teams to design a solution to a problem that uses or expands upon the ideas of prior innovations, persuading their audience of its effectiveness. In addition to completing the performance task, students will explain the life and work of a

scientist and analyze how that person's contributions influenced modern society.

Stage 1: Identify Desired Results

Established Goals (Standards)

NGSS (Engineering Design): 3-5-ETS-1-1. Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time or cost.

ELA 3.2.3.3. Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

Artistic Foundations (K-3) 0.1.2 4.1. Demonstrate skills such as improvising, creating character and selecting costumes for dramatizations.

History (Peoples, Cultures, and Change Over Time) 3.4.2.3.1. Explain how an invention of the past changed life at that time, including positive, negative and unintended outcomes.

What understandings are desired?

Students will understand that scientific innovation has created changes in our society over time, and that there continue to be new discoveries made that will impact our society into the future.

Students will understand the concept of cause and effect as it pertains to history, science and society.

Students will understand that they can apply their own ideas to a problem in order to create change.

What essential questions will be considered?

How has innovation in science and technology changed society?

How can we use our knowledge of past scientific innovation to impact the future?

What is the effect of science and technology on human life?

What key knowledge and skills will students acquire as a result of this unit?

(Students will know... Students will be able to…)

Students will be able to ***argue their position*** for or against an invention in science that has changed society.

Students will be able to ***dramatize the life of a scientist*** who changed society with their invention.

Students will be able to ***formulate a design that solves a problem*** or fulfills a need in modern society.

Stage 2: Determine Acceptable Evidence

What evidence will show that students understand?

Performance Task:

Goal: Your goal is to design a solution to a problem using past scientific discoveries and modern scientific innovations as inspiration.

Role: You are an environmental engineer who wants to improve city parks.

Audience: You will present your idea to local elected officials.

Situation: The city of Arden Hills has realized that storm runoff is damaging the habitats of animals that live in or near the lake and stream at a local park. Your company has been asked to find a solution to the problem.

Product or Performance: Your engineering design team must complete a model and speech that convinces the city board members that your solution will solve the problem.

Standards for Success: Your work must be based on what you know about the successes or failures of past scientific innovations and you must be able to defend how it provides a solution to a current problem.

What other evidence needs to be collected in light of Stage 1 Desired Results?

- Wax museum presentation (dramatize the life of a scientist responsible for an innovation that changed society)
- Group debates:
    - Resolve: The invention of robots has improved society.
    - Resolve: The invention of the computer has improved society.
    - Resolve: The invention of the automobile has improved society.
    - Resolve: The invention of electricity has improved society.

Other Evidence: (e.g., tests, quizzes, prompts, work samples, observations)

- Create a timeline of the process of innovation for a scientific discovery (people involved, where events took place, dates and important discoveries that occurred)
- Compare and contrast the scientist you studied with a classmate's scientist
- Students write a quiz that they can give to the rest of the class after the class has had a chance to view their final performance task
- Notes taken from the texts that were read/viewed
- Self/group assessment rubrics collected
- Teacher questioning/ conferring checklists

Performance Task Assessment and Student Self Assessment:

Appendix C: Scoring Rubrics and Feedback Forms

1. End of Unit Rubric: Group Debate
2. End of Unit Rubric: Wax Museum
3. End of Unit Rubric: Park Project
4. Ongoing Student Self Assessment

5. Work in Progress: Collaborative Work Feedback Checklist
6. Work in Progress: Individual Feedback Checklist

Stage 3: Plan Learning Experiences and Instruction

What sequence of teaching and learning experiences will equip students to engage with, develop and demonstrate the desired understandings?

W How will you help students know ***where*** they are headed and ***why***?

- In order to know where we are going, it is important to be familiar with where we came from. A background in scientific discovery provides a framework for understanding the science and technology we so often take for granted today.
    - Students will research a scientist of their choice and prepare to dramatize their life and work.
    - Frequent group discussion around emerging themes will help students understand why they are learning about the life and work of scientists.

H How will you ***hook*** students through engaging and thought provoking experiences that point toward big ideas, essential questions, and performance tasks?

- Interview with a scientist. Find a community partner that would be willing to meet with the class digitally to talk about their work, how they think about invention and innovation in science, and how it impacts our society.

E What events (real or simulated) can students ***experience*** to make the ideas and issues real?

- Primary source documents about historic scientific discoveries.
- Video/television highlights of new scientific breakthroughs
- Read about/watch video footage of current events in science
- Perspective taking: global science (what is innovative to developing countries?)

What learning activities will help students ***explore*** the big ideas and essential questions?

- Students compare and contrast two or three texts (written or visual) about the scientists and their contributions to society.
- Students create a timeline puzzle about the scientist's life for other students to solve
- Students write an informative essay about a scientist's role in innovation and what effect it had on society (based on virtual/in person interview)
- Partner discussion/interviews: What do our scientists have in common? What were they trying to achieve? Were they considered successful? How do we use their contributions to science today?
- Students create a digital presentation (Google Slides) of the important

information about their scientist and his/her invention or innovation to add to their digital learning portfolio

- Students engage in a debate regarding the impact of science and technology on society
- Students design a solution to the problem of stormwater runoff polluting animal habitats in a local park (Ask: Why did the scientist I studied make their discovery? What need were they trying to fill? What problem were they trying to solve? How can I use what they did to help me work toward my goal?)

What instruction is needed to ***equip*** students for the final performance?

R How will you cause students to ***reflect*** and ***rethink*** to dig deeper into the core ideas?

- Question students as they work through their learning experiences to ensure that they are keeping the big idea and essential questions at the heart of their work, and that they are clear about the connection between the work they are doing and the big idea/essential questions.
- Focus on the why: For example, why do we need to know what scientists have accomplished before us?

How will you guide students in ***rehearsing***, ***revising***, and ***refining*** their work based on feedback and self-assessment?

- Students will work as collaborative groups to give each other advice, support and feedback in preparing their wax museum presentations.

- I will help them refine the language used in their script so that they can fluently and convincingly portray their scientist.
- Guide students through the use of the inquiry cycle with a visual check in and questioning as they work on their design to solve the city park pollution problem.

E How will students ***exhibit*** their understanding about their final performances and products?

- Students will dramatize the accomplishments of a well-known scientist or inventor.
- Students will demonstrate how a scientist might take on the task of innovating a process or product to solve a problem in our modern society.

How will you guide them in self-***evaluation*** to identify the strengths and weaknesses in their work and set future goals?

- During collaborative group work, students complete a group and self evaluation as a way to identify strengths and weaknesses.
- End-of-week student survey to identify what was hard, what went well, and what they would change if they could (this is important feedback in making changes to the overall unit design based on student perspective and experience.

What we think is accessible or valuable may be different than our student's reality).

T How will you ***tailor*** learning to reflect individual ***talents***, interests, styles and needs?

- Working in collaborative groups will allow students to learn from their classmate's strengths as well as to share their own strengths with their team.
- Students will have access to technology for the purpose of researching and gathering information on the scientific innovation of their choice.
- Additionally, students are each accountable for individual performance tasks at the end of the unit, which can be presented digitally or through some other medium (poster board presentation or speech).

O How will you ***organize*** learning to ***optimize*** deep understanding as opposed to superficial coverage?

- Student design process will be organized around the "Ask, Imagine, Plan, Create, Improve" inquiry cycle
- Teacher and student lead discussion of emerging themes.
- Trajectory of the unit's learning plan will be adapted based on findings from formative assessments.
- Students will have the opportunity to communicate with people who have been involved with using specific innovations in various scientific fields

of study.

- Continually tie learning objectives in math and literacy back to the "story" of the unit.

APPENDIX B: STEAM UNIT PLAN TEMPLATE

Appendix B: STEAM Unit Plan Template

Unit Title: Subject/Topic Areas: Key Words: Designed by: School District: School: Grade Level: Time frame:

Summary of Unit (Curricular Context and Unit Goals)

Stage 1: Identify Desired Results

Established Goals (Standards)

What understandings are desired?

(Students will understand that…)

What essential questions will be considered?

What key knowledge and skills will students acquire as a result of this unit?

(Students will know... Students will be able to…)

Stage 2: Determine Acceptable Evidence

What evidence will show that students understand?

Performance Task:

Goal:

Role:

Audience:

Situation:

Product or Performance:

Standards for Success:

What other evidence needs to be collected in light of Stage 1 Desired Results?

Other Evidence: (e.g., tests, quizzes, prompts, work samples, observations)

Performance Task Assessment and Student Self Assessment:

Stage 3: Plan Learning Experiences and Instruction

What sequence of teaching and learning experiences will equip students to engage with, develop and demonstrate the desired understandings?

W How will you help students know ***where*** they are headed and ***why***?

H How will you ***hook*** students through engaging and thought provoking experiences that point toward big ideas, essential questions, and performance tasks?

E What events (real or simulated) can students ***experience*** to make the ideas and issues real?

What learning activities will help students ***explore*** the big ideas and essential questions? What instruction is needed to ***equip*** students for the final performance?

R How will you cause students to ***reflect*** and ***rethink*** to dig deeper into the core ideas?

How will you guide students in ***rehearsing***, ***revising***, and ***refining*** their work based on feedback and self-assessment?

E How will students ***exhibit*** their understanding about their final performances and products?

How will you guide them in self-***evaluation*** to identify the strengths and weaknesses in their work and set future goals?

T How will you ***tailor*** learning to reflect individual ***talents***, interests, styles and needs?

O How will you ***organize*** learning to ***optimize*** deep understanding as opposed to superficial coverage?

APPENDIX C: SCORING RUBRICS AND FEEDBACK FORMS

Appendix C: Scoring Rubrics and Feedback Forms

End of Unit Performance Task Assessment: Group Debate

	1: Beginning	2: Developing	3: Secure
I can thoughtfully state my position on the topic and explain why this is my point of view.	Innocent Student cannot clearly state their position on the topic, instead discussing both sides of the argument or other related topics.	Thoughtful Student can state their position on the topic.	Wise Student *thoughtfully* states their position on the topic of debate and explains why they hold that point of view.
I can provide thorough evidence to support my point of view.	Naive Student provides an example that is loosely connected to their point of	Developed Student provides some evidence that supports their point of view.	Sophisticated Students provides *thorough* evidence in support of their point of view.

	view.		
I can clearly and convincingly argue a point of view different from my own.	Uncritical Student cannot argue a point of view different from his or her own.	Considered Student can argue a point of view different from his or her own.	Insightful Student *clearly and convincingly* argues a point of view different from his or her own.

End of Unit Performance Task Assessment: Wax Museum

	1: Beginning	2: Developing	3: Secure
I can give a polished performance of the events of this person's life in chronological order.	Novice Student tells about events from this person's life, but they are not in chronological order.	Able Student presents events from this person's life in chronological order.	Masterful Student gives a *polished* performance of this person's life in chronological order.
I can give an accurate	Naive Student can tell	Developed Student can	Sophisticated Student gives an

explanation of how this person's invention solved a problem or fulfilled a need.	what the person invented.	explain what the person invented and why it was made or how it was used.	*accurate* explanation of how this person's invention solved a problem or fulfilled a need.
I can give a thoughtful explanation of how the invention may have changed life at that time in history.	Egocentric Student gives an explanation of how the invention is currently used but does not refer to the history.	Aware Student gives an explanation of how the invention was used at that time in history.	Mature Student gives a *thoughtful* explanation of how the invention may have changed life at that time in history.

End of Unit Performance Task Assessment: Park Project

	1: Beginning	2: Developing	3: Secure
I can make a masterful connection between	Novice Student uses the design process to	Able Student is able to come up with a	Masterful Student makes a *masterful*

what I know about past innovations and a current problem using the design process to come up with a solution.	try to solve a current problem without making a connection to past innovations.	design to solve a current problem and makes a loose connection to past innovations.	connection between past innovations and a design solution for a current problem, describing how knowledge of past experimentation and discovery influenced the new idea.
I can give a sophisticated explanation for the effect my team's design will have on the park using a real world situation as context.	Naive Student can give a reason for how the team's design will solve the problem at the park, but does not grasp how to talk about effect.	Developed Student gives a developed explanation for the effect the team's design will have on the park.	Sophisticated Student gives a *sophisticated* explanation for the effect the team's design will have on the park using examples from a real world situation.

I can give a meaningful interpretation of how my team's design might be useful in solving other problems.	Literal Student can describe the team's design and its usefulness in solving the problem given in the performance task.	Perceptive Student can interpret the usefulness of the design in solving other problems.	Meaningful Student gives a *meaningful* interpretation of the team's design and how its usefulness in solving one problem translates to other situations and uses.

Ongoing Student Self Assessment

	1: Beginning (I'm not really sure)	2: Developing (I need some more practice with this)	3: Secure (I can do this with confidence)
I can explain the big idea I have been studying.			

I can explain how the project I completed is connected to the big idea.			
I can state my point of view about the big idea.			
I can make a connection between my life and what I learned.			

Work in Progress: Collaborative Group Work Feedback Checklist

	1: Beginning (We need some teacher help with this.)	2: Developing (We can do this well on our own.)	3: Secure (We are experts at this and can coach other teams.)

Our conversation stayed focused on the discussion topic.			
We made sure everyone got a chance to share their ideas.			
We summarized and recorded what we accomplished this week. (log progress toward goal)			
We made progress toward our goal. (learning objective(s) met)			

Work in Progress: Individual Feedback Checklist

	Yes	No
I can talk about the big idea I am learning about.		
The ideas I am learning about are important.		
I know what my goal is by the end of the unit.		
I get to make some choices about how to reach my goal.		
The daily work, activities and quizzes my teacher gives me are a fair test of what I have learned so far. (Not too hard, not too easy, just right.)		

APPENDIX D: PARTNERS IN LEARNING

Appendix D: Partners in Learning

Partners in Learning	Available Programs/Resources
The Bakken Museum of Electricity and Magnetism www.thebakken.org/school-programs	• Field trips to the museum that explore the connections between history, science and engineering • Outreach educators bring exciting science theater and classroom workshops to the school (closely aligned with grade level science standards). • Bakken Teacher Academy Summer Workshop
The Science Museum of Minnesota www.smm.org/educators	• Field trips to the museum connected to grade level science standards (check out the standards database which connects exhibits, programs and resources to MN Academic Standards by Grade Level). • At school science assemblies available. • The Science House Lending Library

	provides resources that can be checked out to use in the classroom as well as professional development workshops and institutes for teachers.
Minneapolis Institute of Art https://new.artsmia.org/discover/teacher-resources/	• "Full STEAM Ahead" Tours: With a different science or math related theme for each grade level K-5, museum staff guide students through an exploration of artworks and the design process of creating their own artwork. • Curriculum materials for STEAM lessons (oriented toward secondary grades, but could be adapted to primary grades) • Art Adventure Program: trained volunteers bring posters of artworks into the classroom so students can experience art across cultures and time periods. Focused on a common theme (e.g., Amazing Animals, People and Their Environments).
Stepping Stone Theater	• Theater Arts Residencies: classroom

www.steppingstonetheater.org/schoolandcommunity	residencies co-planned by theater staff and classroom teachers around academic goals to bring creativity to learning through storytelling and performance art. Various program lengths and scholarships available. ● Workshop classes: professional teaching artists work with students through performance art to strengthen skills in critical thinking, social/emotional development and physical awareness.
Leonardo's Basement https://leonardosbasement.org/programs/schools-and-community	● Student directed project building residencies: contact Leonardo's Basement for more details on topics, projects and learning opportunities ● Field trips: explore the design/building process using the tools and building materials in the workshop to create a project ● Family Nights: explore engineering, math and art through a project building activity

The Works Museum https://theworks.org/educators-and-groups/	• Elementary engineering resources: science standards for integrating engineering, engineering design process visual, professional development • Field trips: explore the museum and participate in a staff led workshop in which students design something to take home (grade level standards addressed) • Family engineering nights: Works museum staff and volunteers lead activities for parents and students in an open house setting at school
Minnesota History Center http://education.mnhs.org/	• Collection of online resources for studying Minnesota history (e.g., Hmong in Minnesota, Forests, Fields and the Falls) • Field trips: to the History Center (various topics from American Indian History to the Fur Trade) or other nearby state historic site (e.g., Oliver Kelley Farm, Mill City Museum, Fort Snelling, or the Minnesota State Capitol

	• History Live: video conference with a museum educator giving a lesson through first person historical interpretation. (e.g., Inventions that Changed the Nation, 1900s Logging Camp). Lesson plan resources.
The Bell Museum of Natural History https://www.bellmuseum.umn.edu/education/outreach	• Specimen Loans: fossils and rocks, animal bones, pelts, antlers and horns • In School Labs: museum staff bring live animals and work with students to develop critical thinking skills, inquiry and observation as scientists. Various themes (e.g., Animal Adaptations, Pollination and Our Food) • Residency programs: multi-visit, in depth learning around the same themes offered for in school labs. Option to work with museum staff to develop a residency unique to your unit of study.
Mounds View Public Schools Schoolyard Garden Initiative	• Address food equity, community service and environmental sustainability by

(Ralph Reeder Food Shelf) http://bit.ly/2nHHGfR	having students participate in a discussion and the care of a school yard garden. Use garden space as an outdoor classroom for math and science. Spread community awareness of the program through student created stories, news articles, blog posts, etc.
Como Zoo and Conservatory www.comozooconservatory.org/education/schools	• School outreach program: interactive presentation including live plants and animals. Themes vary across grade levels. • Nature's Engineers: inquiry based program. Students build projects using plants and animals as their models for design. • Como Residency Program: partner with Como Zoo and Conservatory to give students an immersive experience into plants and animals with a focus on STEM related activities. Week long learning opportunity, taught at the zoo. Grants

	available.
Minnesota Zoo www.mnzoo.org/education/schools-teachers/	• Extensive offerings available for field trips and programs at the zoo. Guided tours, teacher programs and resources, conservation and STEM focused learning opportunities. • Zoomobile naturalists bring animals to the school for students to learn about the natural world.

APPENDIX E: DIGITAL RESOURCES FOR STEAM UNIT DESIGN

Appendix E: Digital Resources for STEAM Unit Design

Resource/Website	Connections to STEAM
ISTE http://www.iste.org/standards/standards	• Technology standards for teachers and students with a focus on SAMR (Sustitution, Augmentation, Modification, Redefinition) aimed at developing higher order thinking skills • Online professional learning networks • Focus on rethinking education and developing digital citizenship
SciMathMN http://www.scimathmn.org/stemtc/	• Resources for integrating math and science into technology education and engineering for elementary school students • Math and science frameworks for helping teachers translate standards into classroom practice • Math and science best practices, incorporating inquiry, engineering, and instructional technology

Common Sense Media https://www.commonsensemedia.org/educators	● K-12 digital citizenship curriculum, from scope and sequence, to unit breakdown and individual lesson plans ● Ideas and tools for formative assessment and parent communication ● Tips and tools for engaging students with game based learning
SEEK https://www.seek.state.mn.us/	● Environmental education resources for the classroom ● Calendar of outdoor activities open to educators as well as the general public, including a list of partners and destinations across the state of Minnesota ● Scope and sequence for environmental education and resources for incorporating the outdoors into learning
NGSS https://www.nextgenscience.org/framework-k-12-	● Evidence based foundation for standards drawing on current research ● Standards focused on critical thinking and inquiry based problem solving

science-education	• NGSS Framework for K-12 Science Education outlines three dimensions: practices, crosscutting concepts and disciplinary core ideas
Project Zero http://www.pz.harvard.edu/topics	• Variety of integrated, socially relevant topics to explore archived by subject area and level, as well as many projects focused around STEAM learning • Strong focus on civic engagement through the arts and sciences at a global level • Books, articles and videos focused on inquiry, collaboration, digital citizenship, art and science