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STEAM Curriculum: Arts Education As An Integral Part Of Interdisciplinary Learning

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Abstract

This research project contains an extensive exploration of a STEAM (Science, Technology, Engineering, Art, and Math) approach to curriculum and instruction. STEAM is continually growing as an educational model in transition from the STEM educational (Science, Technology, Engineering, and Math) model. The research is a response to a two-fold problem in education: a lack of preparation for future leaders in careers that require innovative-thinking and a need for advocacy for the arts in public education. The literature review provides an expansive look at the present information available on STEAM frameworks, programs, curricula design, and teaching practices. Four emergent themes are illustrated within the research: problem solving practices, inquiry-based thinking, collaboration, and student choice. Currently there is not an official STEAM framework or a comprehensive STEAM curriculum plan for secondary educators. The product that evolved from the STEAM research is a secondary education curriculum plan that includes a semester-at-a-glance, Know-Understand-Do (KUD) charts, learning maps, and unit plans. This interdisciplinary curriculum provides a solution to the research problem as it is intended to promote innovative solutions and the value of arts education. In the discussion, the researcher explains how to utilize the curriculum components to foster interdisciplinary thinking and avoid superficial integrated or cross-curricular lesson plans by implementing the unit objectives.

Keywords: *STEM, STEAM, curriculum, instruction, interdisciplinary, secondary education*

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Chapter 1

Introduction

This research project is a secondary education interdisciplinary curriculum plan, which entails five unit plans, Know-Understand-Do (KUD) charts, and curriculum maps with essential questions, standards, and key concepts. The entire curriculum plan is based on a Science, Technology, Engineering, Arts, and Math (STEAM) framework and each unit combines art or design with a Science, Technology, Engineering, and Math (STEM) discipline. Included in this chapter introduction is an illustration of the researcher's passion for art and education as a result of her Christian faith. There are a variety of published journal articles that discuss the new buzzword in education, "STEAM", and what it looks like in practice. Publications are used to describe the purpose and function of STEAM education as well as the reason that this topic is in need of further research and resources. Additionally, the methods in which data and research were gathered are outlined and the limitations to the research are described.

My Narrative

I chose to formulate a STEAM curriculum plan because I believe that the arts deserve a voice amongst the designated core courses and that they should be viewed as an equivalent instead of supplemental to STEM courses. The concept of STEAM education appeals to me because it validates the arts in addition to fostering innovative, critical thinking skills in students. Our students need to be better prepared for their futures and for careers that demand problem-solving skills. In the real world, content matter is not divided into solitary boxes, but rather it is intertwined and real-life problems require

multiple skillsets. The arts offer more than an outlet for personal expression; they provide "Reasoning ability, intuition, perception, imagination, inventiveness, creativity, problem-solving skills…" (Ruppert, 2006, p.13). Including the arts with STEM subjects in a meaningful manner will provide our students with a well-rounded education and equip them with the skillsets needed to solve complex problems. Art and design can be seen throughout our daily lives in media, architecture, literature, fashion, music, and marketing; it is arts education that allows these careers to flourish.

The functions of art are multifaceted due to its many different influences from society and religion. I am both an artist and a Christian; my journey of practicing both of these roles has forced me to ponder how these two aspects of my life can intertwine and function together for a greater purpose. Art and design have been a large part of my life since childhood as I have always had an innate desire to work with my hands, create, and render my thoughts and inspirations via artistic outlets. This passion and gift has been given to me in order to use it for God's greater purpose. William Dyrness writes about how our passions and desires forge our identities in our everyday lives and can function as a devotion to God, leading us to His presence (2011, p. 5). I am motivated to use my gift as a means to honor and glorify God and illuminate His love and beauty to others. Creating art is not only a service between us and God or us and our society, but also a means of connecting us, our fellow Christians, and God in a continuous conversation in which we can share insight. My artistic ability is a spiritual gift as well as a reflection of the original Creator of the heavens and the earth. All art derives from the Lord who is the greatest Artist. I know from the book of Genesis that all things originate from God and His artistic creation of all things living. I also know that God grants His children artistic

ability because he told Moses to appoint Bezalel to design and construct a temple. The Bible says, "…and I have filled him with the spirit of God, with ability and intelligence, with knowledge and all craftsmanship, to devise artistic designs…" (Exodus 35:31-32, English Standard Version).

With the knowledge that God has granted me with the innate desire to create, I feel led to serve Him by modeling the importance of the arts for my students and stimulating their own artistic abilities. Educators have demanding positions, which is why most of them have an underlying reason for choosing this vocation. Carr, Fauske, and Rushton (2008) make the claim that "Often, the choice of education as a career is based on a genuine desire to serve, to make a difference in the lives of children" (p. 7). I recognize that my desire to be an educator stems from my calling to serve others. According to Hannay, Kitahara, and Fretwell (2010), "The attributes common in servant leaders are very similar to those that characterize effective teachers" (p. 5). The concept of servant leadership intrigues me and I feel that it is what I am called to do and convicted to do as a Christian educator. This STEAM curriculum that I have formulated allows me to combine my desire to advocate for the importance of arts education as well as implement characteristics of servant teaching.

Contextualizing the Problem

In our current society there is ongoing growth in technological advancement and STEM jobs, with a need for individuals to fill positions that will further expand these discoveries with innovative ideas (Vilorio, 2014, p. 5; Keane & Keane, 2016, p. 78). However, there is a lack of preparation and lack of programs for future leaders in careers

that require innovative thinkers and the U.S. is falling behind in scientific innovation (Sharapan, 2012, p. 36; Quiqqley & Herro, 2016, p. 410). Schools have been emphasizing the importance of STEM programs and curriculum to teach and encourage students to pursue careers in these fields because of the idea that, "…STEM fields drive critical innovation and that innovation… is explicitly tied to economics" (Liao, 2016, p. 44; Quiqqley & Herro, 2016, p. 410). According to Ghanbari (2015), STEM jobs are growing three times as fast as non-STEM careers (p. 4). Yackman (2008) states that educational leaders are promoting STEM programs in order, "…to produce more scientists, mathematicians and engineers who are capable of leading the discoveries and developments of the future" (p. 2). The STEM acronym (Science, Technology, Engineering, and Math) was formulated by the National Science Foundation (NSF) in the early 1990's and grew in popularity due to policymakers and the Obama administration's goal to produce more STEM graduates (Ghanbari, 2015, p. 4). STEM refers to groups from each of the four content areas or fields of study working together in order to solve complex, real-world problems (Vilario, 2014, p. 3). The issue is that the number of students pursuing STEM fields is decreasing (Liao, 2016, p. 44). An additional problem is that STEM curriculum excludes the arts or dilutes the impact of the arts and therefore is lacking in teaching creative and innovative thinking (Liao, 2016, p. 45). Vilorio (2014) states that, "Critical and creative thinking help STEM workers in problem solving…" because it helps them to formulate innovative solutions or creatively approach problems (p. 9).

This push for STEM has caused art educators to be concerned about the integrity of art and its place in education (Liao, 2016, p. 45). This is how the STEAM (STEM +

Arts) movement has come to fruition. The National Art Education Association (NAEA) defines STEAM as, "the infusion of art and design principles, concepts, and techniques into STEM instruction and learning" (Liao, 2016, p. 45). According to Quiggley and Herro (2016), there is little research done on STEAM teaching practices and little understanding of STEAM teaching, but the use of STEAM is growing nationally and globally (p. 411). STEAM has made its way into our legislature; there has recently been an amendment to the ESSA (Every Student Succeeds Act) that states that, "…integrating other academic subjects, including the arts, into STEM subject programs to increase participation in STEM subjects, improve attainment of skills related to STEM subjects, and promote well-rounded education" (McClanahan, 2016). The STEAM movement is intended to showcase the Arts as a core subject, not a supplementary elective (Ghanbari, 2015, p. 2). A STEAM curriculum framework is a solution to the need for more creative, innovative thinkers in the workforce and a solution for the need to validate the arts in education.

Purpose of the Study

STEAM is still in the process of gaining momentum as an educational model. According to Watson (2016), STEAM best practices are still in need of exploration, but, "We are beginning to see trends; anecdotally, we see successes when STEAM is blended with inquiry methods such as Project-Based Learning and metacognitive constructs such as Design Thinking" (p. 9). The seemingly disparate disciplines have similarities that would make integration a possibility. Bequette and Bequette (2012) claim that art and engineering both require complex cognitive processes and that, "Art, like engineering, is concerned with finding answers to problems and seeking visual solutions using the design

process" (p. 44). There are some schools that are beginning to implement a STEAM program, but it is still a new and growing concept. For educators, there are no cohesive curriculum plans, nor are there specific STEAM program frameworks available to build a STEAM program or curriculum in secondary schools. Ghanbari (2015) stated that, "…at this point there is minimal research sharing the process of creating STEAM based curriculums and partnerships" (p. 2). Due to this need for more STEAM curriculum resources, the purpose of this project is to create a secondary education STEAM curriculum plan that utilizes a STEAM framework. This semester-long curriculum plan has units that contain cross-curricular standards and goals for projects that will foster creative, innovative, and critical thinking. Each unit of the curriculum plan integrates art and/or design with a STEM discipline. The overall plan creates a true collaboration amongst disciplines and promotes holistic learning by including the Arts with logic-driven content areas. Since there are not many STEAM tools or resources readily available for educators, there are many STEM lesson plans that include an Art element as an after-thought to a project (Quiggley & Herro, 2016, p. 411). In contrast, this STEAM curriculum starts with an authentic, meaningful Art component that is enhanced with one or more STEM components. The overall goal is to demonstrate intentionality in the combination of disciplines in order to meet curricular standards and objectives of more than one content area.

Methodology

In formulating a STEAM curriculum plan, extensive research on the concept of STEAM, as well as implementation of STEAM programs or curriculum, will be

explored. Data from academic journal articles will be collected, reviewed, and organized according to common themes of project-based learning, integrated curriculum, and transdisciplinary thinking. Also, data will encompass information regarding the following: STEAM education frameworks or models, examples of a transition from STEM to STEAM, and STEAM teaching practices. Comprehensive research efforts in constructing a curriculum plan provides a research-based STEAM framework and teaching practices that will be utilized as a foundation for each unit. Organizing the literature and research by common themes allows the researcher to recognize the voids or limitations in the research in this topic.

Limitations to the Study

Future mixed-method studies are needed to study the effects of integrating the arts with STEM disciplines and determine whether a STEAM framework solves the problem of lack of innovation and creative thinking needed for growing STEM careers. Some information is lacking on the topic of a STEAM interdisciplinary curriculum framework, and ongoing research is needed for determining the efficacy of the framework and proposed models. One of the areas in need of more research is a secondary education STEAM program. The literature appeared to focus on elementary and collegiate level students. There is a need to determine what a STEAM program looks like in comparison to a STEM program and whether arts integration enhances overall academic success for secondary level students. Current research also does not conclude whether the integration of arts education promotes innovative thinking more than the seclusion of disciplinary studies. It would be beneficial for this research topic to collect quantitative

data on its efficacy as well as more qualitative data regarding secondary-level teacher observations and student-based reflections regarding their attitudes toward STEAM.

Another limitation is lack of time and resources for secondary-level educators to collaborate amongst themselves in order to create and implement a truly integrated STEAM curriculum. In order to thoroughly meet cross-curricular objectives and standards, educators would need to collaborate and/or co-teach so that an educator with expertise teaches each content area of the particular unit. Otherwise, the STEAM curriculum runs the risk of glossing over one of the STEM objectives or adding an art project as an after-thought that does not require critical thinking skills to complete. Common planning time for teachers is not prevalent in many secondary schools and it requires administrative participation and planning.

STEAM holds the view that the arts possess equivalent value to the math and science courses. However, there may be remaining stigma against the arts as a core subject that impedes a successful integration of the arts with STEM disciplines. As the arts are not a state-tested subject and the arts courses are labeled as electives, they are still viewed as a nonessential or a supplemental element to a student's education. This stigma could deter STEM teachers from making time for collaboration with the arts educators and revising curriculum.

Definition of Terms

The following terms are operationally defined for the study:

STEM: Science, Technology, Engineering, and Math

STEAM: Science, Technology, Engineering, Art, and Math

PBL: Project-based learning, "PBL is the ongoing act of learning about different subjects simultaneously." (Wolpert-Gawron, 2015)

Interdisciplinary: Integrating several disciplines in curriculum (Quiggley & Herro, 2016)

Transdisciplinary: Curriculum that starts with a problem to be solved using different solutions, viewpoints, or perspectives (Quiggley & Herro, 2016)

Chapter 2

Literature Review

In the world of education today, accountability is becoming unavoidable; educators are to ensure their students' success and provide preparation for their students' futures. The public school curriculum is a large part of the accountability that educators must face. In recent years, there has been a growth in demand for a STEM (Science, Technology, Engineering, and Math) program in schools to develop students in these content areas in order to best prepare them for careers in these growing fields. However, a STEM program does not incorporate the Arts, which may be an integral piece to interdisciplinary education and an essential element for STEM careers that demand innovative thinking (Grinnell and Angal, 2016, p. 54). According to Tillman (2015), "In education, mathematics and science are often taught in a manner that lacks opportunities for students to engage in creativity and the arts are allotted less time…" (p. 301). Clapp and Jimenez (2016) assert that, "In an economic and political landscape that strongly favors education in the STEM subjects, the STEAM agenda certainly appears to be a viable means of reprioritizing the arts into the educational lives of young people" (p. 482). This twofold problem may have a solution in a STEAM curriculum framework that integrates the arts with STEM disciplines.

Approaches to STEAM Curricula Design

There is a variety of research on a STEAM interdisciplinary or transdisciplinary approach that examines the relationship between the arts and STEM content. According to Yakman (2008), "STEAM is a developing educational model of how the traditional

academic subjects (silos) of science, technology, engineering, arts and mathematics can be structured into a framework by which to plan integrative curricula" (p. 1). The objectives of STEAM are to reconstruct research policy, advocate integration of Art education in K-12, and to motivate employers to hire artists and designers to stimulate innovative thinking (The Congressional STEAM Caucus, 2013). The following journal articles investigate the application of this actively growing curriculum framework.

Mixed-Methods

In a mixed-methods design approach, researchers examined STEAM integrated curriculum and pedagogy of pre-service elementary teachers using peer-evaluation surveys and open-ended interview questions. The quantitative data elicited from the surveys about STEAM lesson plans was intended to identify possible differences between pre-service elementary teachers that are bilingual generalist regular generalist, or an undecided generalist (Tillman, 2015, p. 314). In this study, bilingual generalists refers to those who intend to teach in Spanish and in English, regular generalists refers to the regular elementary education majors, and undecided generalist refers to those in an education program who have undecided tracks (Tillman, 2015, p. 303). Qualitative data was elicited from the teachers via interviews regarding their perspectives and attitudes about the curriculum.

The peer-evaluated surveys were formulated using a scale that evaluated seven objectives: "(1) Do the lessons creatively demonstrate innovative ways of teaching mathematics or science? (2) Is lesson content closely related to the lesson objectives in a creative manner? (3) Was there creativity used in developing an enjoyable learning environment? (4) Are there enough creative challenges presented for students? (5) Are

the arts components creatively integrated with the mathematics? (6) Do the lessons try to creatively create an equitable learning environment that respects all students' ideas? (7) Are there enough choices for students to creatively choose their own ways to solve the problems?" (Tillman, 2015, p. 313). The open-ended interview questions asked the teachers to compare and contrast their lessons with the others' lessons in terms of authentic creativity (Tillman, 2015, p. 313). Results show that all groups of teachers had the most success with, "including creative innovation and creative connection" and the least amount of success with, "including creative challenges and creative choices" (Tillman, 2015, p. 320). Overall, there were very few differences among the three sets of teachers who participated in the study (Tillman, 2015, p. 323).

The Pyramid Model

Using a pyramid style diagram, Yakman (2008) created a model for STEAM curriculum that is founded on investigations of historical practices of specific fields of education and educational psychologists' theories. Her definition of STEAM is, "Science and Technology, interpreted through Engineering and the Arts, all based in a language of Mathematics" (Yakman, 2008, p. 18). The motivation for this model was to eradicate a hierarchical system in which some disciplines dominate and others become overshadowed or eliminated (Yakman, 2008, p. 11). The pyramid has four levels that begin with content-specific material that transition to a holistic approach at the top level (p. 17). She described the relationships among the disciplines as important because we cannot have one discipline without the other (Yakman, 2008, p. 17).

Yakman's research led to findings that a STEAM framework brings about functional literacy in which students become capable of thinking across spectrums and

making connections between multiple disciplines (2012, p. 1075). She claimed that, "This also assists them to better understand people and things rooted in other disciplines, perspectives and cultures so they can communicate and work with one another while still maintaining their own identities" (Yakman, 2012, p. 1075). Moreover, Yakman stated that students could achieve more depth of knowledge when knowledge is transferred from one discipline to another, which in turn is applicable to the real world (2012, p. 1076). She suggested that, "Teams of teachers can work together to provide in depth coverage of their areas of expertise while reinforcing what students are learning in other specific areas" (Yakman, 2012, p. 1078). Her findings also discovered a relationship between the STEAM framework and the theories of cognitive and educational psychologists such as constructivism, Vygotsky's theory of proximal development, Gardner's Multiple Intelligences, Marzano's Strategies, and Bloom's Taxonomy (Yakman, 2012, p. 1079-1080).

Interactive Art Approach

The authors Radziwill, Benton, and Moellers (2015) investigated what it means to learn in a STEAM context and how to assess STEAM learning. They suggested that the answer to a successful integrative arts-integrated curriculum revolves around interactive, participatory, and dialogic art (Radziwill et al., 2015, p. 2). Interactive art is claimed to, "…promote the discovery and development of meaning" and engage participants in a reflective experience (Radziwill et al., 2015, p. 3). Participatory art is intended to provide an open-ended narrative and dialogic art is a means of collaborating and creating meaning through dialoguing (Radziwill et al., 2015, p. 3).

In an attempt to make STEAM tools more meaningful and applicable, the authors formulated a model to be utilized, "… as a vehicle for creating complete and meaningful experiences" (Radziwill et al., 2015, p. 3). The model for STEAM learning involves (1) learning on four different levels (2) a creative ecosystem (3) learning that occurs in an arbitrary, irregular fashion (4) future career benefits may not be immediate (5) learning is emergent (Radziwill et al., 2015, p. 4). The four different levels of learning include: stocks of knowledge, flows of knowledge, the changing of self-perception, and the changing of others' perceptions of the learner within the network (Radziwill et al., 2015, p. 4). They stated that this model and the four levels of learning could be utilized to assess STEAM learning; the intent should be to determine the acquisition or development of skills and where or how meaning has been made (Radziwill et al., 2015, p. 5).

STEM to STEAM Examples

As STEM programs have become widely accepted as beneficial for school curriculum, there have been questions as to how the Arts fit into the picture. Some researchers have explored how a STEM framework can transform into an integrated STEAM framework. Authors Wynn and Harris (2012) claimed that art and STEM disciplines are of equal importance and that a STEAM framework would catalyze a shift in academic success for American students (p. 42). They stated that this type of framework is successful because it allows left-brained thinkers to visualize real-world applications of math and sciences and helps visual or strategic thinkers to view hard sciences as less threatening (Wynn & Harris, 2012, p. 43).

The Watershed Project

Wynn and Harris (2012) interviewed art educators for ideas on implementing interdisciplinary topics and they provided a middle school project that exemplifies an integrated curriculum. At RMS Middle School, a team of teachers consisting of the math, science, and art teacher worked together to formulate and lead a Watershed project in which the 6th grade students created a mosaic as a visual representation of the human impact on the environment (Wynn & Harris, 2012, p. 46). They learned about natural processes in the environment, conservation, and ecosystems. Each student kept a sketchbook in which they used to collect information and sketch works-in-progress. The teacher team took the students to do field work on the river and to an art museum with their sketchbooks to note questions and observations. According to Wynn and Harris (2012) this type of learning is important because, "Art students become better technicians and conceptual thinkers through STEAM, while science students become more imaginative and innovative" (p. 47).

The Aesthetic/Analytical Mode of Thought

Adding to this conversation are the authors Bequette and Bequette (2012) who argued that, "…interdisciplinary work in the arts and sciences can lead to curricular components that combine aesthetic and analytical modes of thinking to the betterment of both science and art" (p. 43). They discussed how the artistic and design processes are similar to problem solving processes used in the STEM disciplines, which make them capable of melding together seamlessly. "Pedagogically, both art and engineering education lend themselves to problem-based learning (PBL), a way to motivate and integrate authentic learning in a discipline" (Bequette & Bequette, 2012, p. 44).

STEAM in the Everyday World

In another example of transitioning from STEM to STEAM, Sharapan (2012) suggested that early childhood educators should apply Fred Rogers' approach to learning by, "…facilitating inquiry-based thinking and discovery" instead of presenting straight facts (p. 37). She explained that utilizing the arts in curriculum allows children to express STEM concepts (2012, p. 36). According to Sharapan (2012) each of the STEAM disciplines elicits important skills or processes; science creates a sense of wonder and curiosity, technology provides tools to be utilized, engineering illustrates that problems have solutions, art promotes creativity and communication, and math provides opportunity to compare and sort patterns (p. 37). Sharapan (2012) believes that STEAM can be found in everyday life and that early childhood educators can take advantage of teaching these concepts as they arise naturally (p. 37). In addition to building on natural consequences, Sharapan (2012) suggested to expand on children's natural interests, encourage and appreciate their questions, invite visitors who work in STEAM careers such as a project manager to the classroom, and create a meaningful context for learning through discussions and relevant learning (p. 38-40).

Brock, Dunifon, and Nagel (2016) reiterated this practice with the claim that children learn better with relevant subject matter because they need to connect ideas to help explain the world around them (p. 49). They argued that the connections between literature, the arts, and STEM are important to curriculum and learning (Brock et al., 2016, p. 49). "Projects that fuse the arts with scientific inquiry are complementary and require students to engage in critical and creative thinking" (Brock et al., 2016, p. 49). Their article summarized a large-scale STEAM project, which derived from a thematic extension of a novel involving 5 elementary schools and a local zoo (Brock et al., 2016,

p. 49). These schools communicated via Skype and blogging, they collaborated with the local zoo, the teachers shared resources, and students were assessed using technology applications such as Wordle, Animoto, or PowerPoint (Brock et al., 2016, p. 49-50). The overall project consisted of the students conducting investigations with the zoo educators to design and create dioramas, small literature circle discussion groups with each student assigned a specific role, designing and creating animal crates with puzzle feeders intended to simulate transportation of animals, and a study of gorilla paintings and creation of original student artwork (Brock et al., 2016, p. 50-51). Throughout the entirety of this project the students employed processes and practices from each of the STEAM disciplines. The art element was not an after-thought, but rather it was meaningfully incorporated into the unit. Students compared gorilla paintings to the work of abstract artist Jackson Pollock and discussed elements of art used to elicit an emotional response (Brock et al., 2016, p. 51). The unit was concluded with the students creating an original abstract watercolor painting with the goal of eliciting an emotional response from their audience (Brock et al., 2016, p. 51).

Interdisciplinary and Transdisciplinary Education

The STEAM educational model is not a completely new concept as it is based on the idea of integration of subject matter and collaboration amongst educators. Berk (2016) considers "…interdisciplinary and hybrid interactions between diverse methodologies and skills" to be the solution to solving the complex challenges of today's society (p. 16). Keane and Keane (2016) state that integrated arts education allows students an opportunity to learn and discover the world (p. 63). Guyotte, Kellam, Constantino, and Sochaka (2014) suggested that we should view STEAM as, "…a means

toward overcoming the compartmentalized disciplinary approach to education" (p. 12).

The Transdisciplinary Design Studio

Authors Guyotte et al. (2014) discussed interdisciplinary thinking as a social practice and they described contemporary artists whose works explore themes that are transdisciplinary in order to illustrate how the arts are not disparate from the sciences (p. 13). Likewise, they described how engineering could also be viewed as a social practice in which the goals revolve around "social and ecological justice" (Guyotte et al., 2014, p. 13). With this concept, a Transdisciplinary Design studio was created for undergraduate and graduate students of art education, landscape architecture, and civil and environmental engineering programs (Guyotte et al., 2014, p. 14). These students were given two design challenges given the problem of sociotechnical complexities of waste and water sustainability and were expected to collaborate in order to create a presentation of their concepts and process of the solution to the problem (Guyotte et al., 2014, p. 15). The challenges that these students were given had motivated them to utilize creative thinking skills and arts-based inquiry methods such as, "…observing, recognizing patterns, empathizing, playing and synthesizing." (Guyotte et al., 2014, p. 14-15). One of the engineering students reflected on the challenge as a beneficial experience because it "…helped her develop a deeper understanding- not only of other disciplines, but also of her own" (Guyotte et al., 2014, p. 17). The instructors saw the STEAM framework emerge throughout this process in three stages, consisting of: "Thinking Through Materials, Considering Audience, and Engaging with Community" (Guyotte et al., 2014, p. 17).

Disciplinary-based Understanding

Furthering this discussion in another qualitative account, Guyotte, Kellam, Constantino, and Sochaka (2015) shared a collection of narratives from art education students' experiences with "disciplinary-based understandings of creative thinking" in the aforementioned Transdisciplinary Design Studio (p. 2). The authors used a visual-verbal method of research in order to collect findings on the students' experiences and perceptions of creativity via visual journals, focus groups, and a reflective paper (Guyotte et al., 2015, p. 3, 9). The purpose of this study was to determine co-equal benefits for STEM students as well as the Arts students when utilizing a STEAM curriculum (Guyotte et al., 2015, p. 6). Some of the questions that the students were asked include: "What are the most significant things you learned? How has this knowledge affected the manner in which you perceive or approach problems? How do you envision applying this knowledge to future experiences in your profession?" (Guyotte et al., 2015, p. 13). This study shows that there was a prominent theme regarding the battle of process versus product, because our education systems create a mentality of completion for the grade as opposed to focusing on the process of achieving the product. One of the participants stated that she, "…observed, firsthand, how people from different disciplines can interact together and solve problems…" (Guyotte et al., 2015, p. 28). The authors termed this trend as collaborative or distributed creativity, "… where the goal was the generation of a shared, yet unpredictable creative product" (Guyotte et al., 2015, p. 29). Reflections from the interdisciplinary groups of students determined that creativity was a common language in which the students were able to utilize and collaborate across disciplines (Guyotte et al., 2015, p. 30). Overall, Guyotte et al. (2015) claimed that these student

experiences demand a reexamination of pedagogy "…in order to thoughtfully orchestrate collaborative and creative learning" (Guyotte et al., 2015, p. 31).

Transdisciplinary Enrichment: Creative Problem Solving

Liao (2016) was also interested in how STEAM enriches transdisciplinary thinking and how the arts play a role in transdisciplinary curriculum (p. 44). She made the argument that arts integration practices are diverse and the arts, "…offer an important way to cultivate creativity" (Liao, 2016, p. 44-45). In order for educators to formulate a transdisciplinary space, the art and design educators need to collaborate with the STEM educators and determine how their students can learn via creative problem solving (Liao, 2016, p. 45). Liao (2016) warned that there could be confusion between the implementation of arts-integration and STEAM; she explained that arts-integration is often misconceived as an enhancement to learning instead of an equally important subject (p. 45; Berk, 2016, p. 16). A true STEAM curriculum views art as a vehicle for learning and the center of its approach is creative problem solving through creation and production (Liao, 2016, p. 45-46). She clarified that a transdisciplinary transformation requires a focus on process and skills instead of the end product, a growth of collaborative skills, and nourishment of students' abilities and transferrable skills (Liao, 2016, p. 46-48). According to Liao (2016), transdisciplinarity is essential for solving global problems with innovative solutions (p. 48). She outlines three ways to determine transdisciplinarity: connection to real-world settings, the ability to explain implications of projects, and the ability to apply knowledge and skills in new areas (Liao, 2016, p. 48).

Integrated Thinking

Muir Woods Project

Integrated education grants students with an opportunity to, "…see natural connections between typically discrete subjects, and it has the potential to increase student interest and achievement in all related subject areas" (Moreno, Tharp, Vogt, Newell, and Burnett, 2016, p. 889). Marshall (2016) provided a school-age illustration of integrated thinking through the example of a 3rd-grade Muir Woods Project in a charter school in California (p. 13). The project consisted of students taking a field trip to the national park after studying ecology and Muir Woods history; the students were required to do individual explorations on the field trip using field study visual journals (Marshall, 2016, p. 13). Students had, "…constructed, accumulated, and recorded their learning over time" by juxtaposing visual imagery with written explanations, observations, and reflections in their journals (Marshall, 2016, p. 15). This type of project is an example of a unique type of arts integration in which arts-based inquiry triggers the integration that occurs via "…methods, tools, and thinking from various disciplines- such as observation, critical analysis, synthesis, questioning, connecting and reflection" (Marshall, 2016, p. 16).

The Muir Woods Project exemplifies arts-based inquiry as it allowed students to visualize their ideas from a different perspective and forced them to combine analytical with nonlinear thinking (Marshall, 2016, p. 16-17). According to Marshall (2016), this type of integrated thinking fosters "poietic logic" in which learners understand how varying elements of academia fit together and connect to the real world (p. 18). She defines poietic logic as, "…a distinctive kind of thought that mingles analytical, logical,

and linear reasoning with nonlinear and associative thinking" (Marshall, 2016, p. 17). Marshall (2016) reminded us that although studies have found a correlation between the arts and high academic achievement, causation has not been identified and for that reason, the Arts must demonstrate cross-disciplinary ideas that "…enhance academic knowledge and build cognitive skills" (p. 18). She suggests that art should act as an adhesive and a catalyst for curriculum (Marshall, 2016, p. 18).

Barnes Foundation Elementary Program

Glass and Wilson (2016) summarized a program that used art as a foundation and catalyst for an integrated approach. The staff at the Barnes Foundation, a visual art gallery in Philadelphia, felt that it would be beneficial to use science and math in congruence with their art collection in order to teach problem solving using creative and critical thinking (Glass & Wilson, 2016, p. 8). Over the course of their STEAM curricular design, the education staff found that their focus shifted from integration of content areas to the practices of math and sciences (Glass & Wilson, 2016, p. 8). This particular outreach STEAM program was offered to 5th and 6th grade students in Philadelphia and consisted of guided tours of the gallery and hands-on activities (Glass & Wilson, 2016, p. 10). Studies have found that students rarely use math and science vocabulary when discussing artwork (Glass & Wilson, 2016, p. 10). In this curriculum the educators used the artwork to teach concepts such as light vs. shadow, color and light physics, geometric shapes, and coordinate planes (Glass & Wilson, 2016, p. 10).

STEAM Teaching Practices

Glass and Wilson (2016) caution art educators to steer away from trying to teach STEM disciplines in which they may have limited content knowledge or pedagogy (p.

10). They suggest that art educators collaborate with content area specialists to further delve into the math and sciences integrated in the lessons and find similarities in habits and processes between the National Core Arts Standards and STEM Common Core standards (p. 10). Additionally, authors Bequette and Bequette (2012) stated that a STEAM framework runs the risk of constructing a curriculum that does not truly integrate and discuss multiple disciplines, but instead creates a disservice to the students involved and a disservice to the discipline itself (p. 46). They also advise art teachers to offer problem-based lessons and to reach out to STEM teachers using a language of functional design, and base projects on engineering topics and 21st century skills (Bequette & Bequette, 2012, p. 46).

Berk (2016) asserts that future STEAM models should emphasize teaching habits and skills instead of a conglomerate of knowledge, because that is how students will be able to, "…solve complex, system-level problems that cross disciplinary boundaries" (p. 16). Glass and Wilson (2016) recommend that educators transition to STEAM practices slowly by focusing on big ideas, fundamental concepts, practices, and habits of mind that connect the arts with the sciences (p. 10). Their STEAM design principles include: ground everything in the artwork, create discovery-oriented projects, and implement 'looking' strategies for making evidence-based inferences (Glass & Wilson, 2016, p. 11). Clapp and Jimenez (2016) echo the importance of true incorporation of the arts in STEAM by stating that it is imperative to be intentional about using arts-based concepts and practices and utilizing maker-centered learning experiences (p. 489).

Inquiry-based Learning

Several of the STEAM literature reiterated common themes of problem solving,

inquiry-based thinking, collaboration, and incorporation of student choice as key elements to a STEAM based curriculum. Sharapan (2012) claimed that STEAM should be about, "…facilitating inquiry-based thinking and discovery" instead of facts (p. 37). According to research, inquiry-based learning increases students' content knowledge in science, students are able to transfer knowledge, and it promotes success in math and engineering (Keane & Keane, 2016, p. 62; Grinnell & Angal, 2016, p. 54; Quiggley & Herro, 2016, p. 412; Ghanbari, 2015, p. 3). Another study found that art coursework that was combined with an engineering program allowed the engineering students to capitalize on inquiry-based thinking (Ghabari, 2015, p. 3). Ghanbari (2015) stated that, "Artistic inquiry promotes rigor and creativity while also enabling an instructor to teach in multiple ways which in turn creates …a higher probability of retaining knowledge" (p. 5). Liao (2016) states that one of the signs of transdisciplinary learning is the students' ability to apply knowledge or skills in new areas (p. 45).

Problem Solving Practices

In addition to inquiry-based learning, STEAM is also founded on problem solving. According to Glass and Wilson (2016), "Many STEAM programs are designed around Project Based Learning (PBL), which features student choice in creatively and collaborative solving relevant problems…" p. 10). Quiggley and Herro (2016) state that active, investigative thinking requires problem solving, creativity, and innovation (p. 413). They define transdisciplinary teaching as starting with a problem that needs to be solved and going, "beyond the disciplines" to promote finding different solutions (Quiggley & Herro, 2016, p. 412). The inclusion of the arts, design, and humanities is intended to create a balance in the curriculum, "…to promote students to solve the

world's pressing issues through innovation, creativity, critical thinking, effective communication, collaboration, and ultimately new knowledge" (Quiggley & Herro, 2016, p. 410). Liao (2016) emphasizes that creative problem solving through creation and production needs to be the center of a STEAM approach (p. 46).

Collaboration

Grinnell and Angal (2016) attest that adding the 'A' to STEM gives students an opportunity to work effectively together (p. 54). In one elementary STEAM unit, Shorter and Segers (2016) witnessed students working together in groups with their art teacher and collaboration occurring amongst the students and the experts (p. 43). Keane and Keane (2016) confirmed similar observations in elementary and middle school STEAM workshops in which students collaborated in order to brainstorm and revise proposals for their designs (p. 65-8). One of the emergent themes of a qualitative research on STEAM practices was collaborative learning (Ghanbari, 2015, p. 10). Research findings show that STEAM practices provide students with dynamic, interactive learning experiences (Keane & Keane, 2016, p. 62). STEAM curriculum should promote collaborative learning via conversation and constructive criticism amongst peers in order to come to a solution as a team (Ghanbari, 2015, p. 10). STEAM should be integrated into pedagogical practices by focusing on processes and skills and the growth of collaborative skills instead of the end product (Liao, 2016, p. 46).

Student Choice

Lastly, true STEAM practices incorporate student choice in order to make the content relevant for the students (Quiggley & Herro, 2016, p. 417; Sharapan, 2012, p. 38). In addition to relevance, choice makes the learning more meaningful for students,

they are able to enjoy learning with engaging classes, become excited about their coursework, and feel a sense of ownership (Ghanbari, 2015, p. 10; Shorter & Segers, 2016, p. 43). Student choice provides students options in applying their knowledge or information learned even though the same material was covered with all students (Quiggley & Herro, 2016, p. 419). Shorter and Segers (2016) state that STEAM and PBL engage and motivate students because it allows them to create a real product which piques their interest throughout the process (p. 46). STEAM adds, "…a creative value-driven edge to STEM" that connects imaginations with a real purpose, transforms disciplinary-based instruction to transdisciplinary practices, develops student abilities and captures student interests (Keane & Keane, 2016, p. 62).

Chapter 3

Curriculum Plan

This section includes the documentation for the STEAM curriculum plan. The curriculum plan begins with a semester-at-a-glance that outlines the overall foundation of the units. The National Visual Art standards are placed next to the STEM standards in a chart in order to give a visual of how the two selected disciplines connect and converge to formulate the essential questions. Each standard is labeled and described to show the importance of utilizing curricular standards from more than one discipline to create a true STEAM curriculum. Following the overarching semester-at-a-glance are the learning maps, K-U-D (Know-Understand-Do) charts and unit plans.

Each of the five unit plans were designed backwards by building upon the skills and concepts that are to be demonstrated by the students. Backwards design is a curriculum process in which the summative assessments are determined prior to the unit and lesson plan details (Auger & Rich, 2007, p. 146). The concept of backwards design originates from Wiggins and McTighe, who suggest that effective curriculum planning requires educators to begin with the end or final destination in mind (Auger & Rich, 2007, p. 146). The three stages of planning that are recommended by Wiggins and McTighe are: “1. What is worthy of understanding? 2. What is evidence of understanding? 3. What experiences will promote understanding and interest? “ (Auger & Rich, 2007, p. 146).

The learning map and K-U-D chart precede each unit plan in order to demonstrate the importance of the big understanding that serves as a foundation for each unit. The ‘Know’ goals are to contain factual knowledge such as vocabulary definitions, names, or

dates (Hempfield School District, 2010, p. 30). The 'Understand' goals are to show a relationship between concepts or answer "why?" or "how?" (Hempfield School District, 2010, p. 30). Finally, the 'Do' goals are to be transferrable skills that apply to other contexts or disciplines and represent authentic practices of a particular field or discipline of study (Hempfield School District, 2010, p. 30). Formulating K-U-D charts prior to constructing unit plans enforces backwards design by eliciting the educational intentions for the overall unit. What basic information do the students need to know in order to fully comprehend or understand the concepts being taught? What concepts do the students need to fully comprehend before they can complete complex tasks such as analyzing, creating, or producing? Essentially, the purpose of the K-U-D charts is to initiate the process of backwards design.

Ensuing the student learning maps and K-U-D charts are the unit plans. Each unit plan reiterates the standards, essential questions, and instructional objectives. Also included in the plans are a list of the learning activities and technology integrations that contribute to the instructional objectives. The learning activities also list the suggested anticipatory set, guided practice, teacher modeling, modifications or accommodations, and resources. Each unit ends with a rubric to be utilized for any discussion posts and an analytical rubric for a summative assessment of the end product. Each component within the unit plan is intended to be a procedure or activity that leads to the predetermined objectives and assessments.

Practical Solution

Each of these components that build upon each other to frame a STEAM curriculum plan are a practical resource for secondary educators. Instead of the traditional

lesson plans that are designed for solitary secondary courses, these unit plans are based upon two or more disciplines' standards, concepts, and skills. These foundational standards and concepts are intended for secondary STEM and art educators to initiate collaboration amongst each other for further planning and implementation of STEAM teaching practices. By implementing these plans, secondary educators will be able to foster creative and critical thinking, demonstrate the importance of collaboration, and advocate for the value of art and design within education.

At the secondary level it is difficult for educators to find the time and resources to collaborate; it is especially difficult for educators from differing content areas to collaborate. The components of the STEAM curriculum plan alleviate part of this problem by providing the basis with which to implement interdisciplinary units. Educators may choose to co-teach or parallel teach these outlined units. With cohesive art and STEM standards and objectives, educators can share resources and offer their content knowledge and pedagogy to one another that builds upon these objectives. Moreover, students will be able to model the collaboration that occurs between their educators. Overall, the STEAM curriculum plan should eliminate lesson plans that gloss over important skills and concepts in cross-curricular projects, and replace them with projects that provide deeper understanding of two or more disciplines and showcase the value and integration of arts in education.

Curriculum Application

Due to the progressive nature of STEAM education, educators cannot simply undergo a complete overhaul of their existing curriculum or teaching practices and strategies. To maintain the integrity of a true interdisciplinary curriculum, educators need

to make small changes. All secondary educators can utilize the pieces of the STEAM curriculum plan as a means for experimenting with interdisciplinary projects. This may involve selecting one of the unit plans to utilize for a semester long course. Educators may decide to implement one or two STEAM units from the curriculum plan as a preliminary phase to a full adoption of a STEAM curriculum.

The curriculum plan can also be used as a means for initiating collaboration amongst the educators of the math and sciences with the arts and humanities. It would be extremely time-consuming to search and compare standards from various disciplines and plan lessons with another educator. The similarities amongst the logic driven courses and the arts are not always apparent. By starting with the aligned standards and objectives, educators from various STEAM disciplines have a starting place for coproducing lesson plans or simply sharing resources from each other's curriculum. If schedules and class size permits, educators may choose to use the curriculum to co-teach a unit. Each educator uses their expertise in their content area to share information, initiate class discussions, and model skills or practices for the students.

There are various options for educators to teach the skills and concepts that are listed in the learning maps and K-U-D charts. The curriculum plan does not need to be used in its entirety, but the learning maps and K-U-D charts should lay the groundwork for a backward design. The unit plans should be a foundation for building individual lesson plans that meet the school's specifications for curriculum. Each educator can revise or augment the outlined learning activities to meet their students' needs. It is not intended to be a stringent plan, but rather a tool for implementing STEAM teaching

practices. The learning objectives and essential questions may spark ideas for peer collaboration or technology integration that is not included in the unit plan.

Semester-at-a-glance

UNIT	APPROX. WEEKS	ESSENTIAL QUESTIONS	NATIONAL VISUAL ART STANDARDS	CROSS-CURRICULAR STANDARDS
Conservation Art Creations	4 weeks	How do consumer demands affect the use of natural resources? How can we prevent, control, or reduce waste in our environment? What materials and methods of artistic practices can be used in order to create art and design that affects social change?	VA.CR.1.1.HSIII: Visualize and hypothesize to generate plans for ideas and directions for creating art and design that can affect social change. VA.CR.1.2.HSII: Choose from a range of materials and methods of traditional and contemporary artistic practices to plan works of art and design. VA.RE.7.1.HSII: Recognize and describe personal aesthetic and empathetic responses to the natural world and constructed environments. VA.PR.6.1.HSI: Analyze and describe impact that an exhibition or collection has on personal awareness of social, cultural, or political beliefs	**Environment and Ecology Standards:** 4.3.10A Evaluate factors affecting the use of natural resources. 4.5.10A Explain how public policy encourages or discourages the sustainable use of natural resources. 4.5.10D Evaluate various methods of managing waste as related to economic, environmental, and technological factors.

			and understandings.	
iPad Logo Designs	3 weeks	How are the elements of art and principles of design used to convey meaning in graphic design? How do artists and designers create works of design that effectively communicate? How can we use technology to create an original logo design for a company?	VaCr1.1.HS1: Use multiple approaches to begin creative endeavors VA.RE.7.2.HSII: Evaluate the effectiveness of an image or images to influence ideas, feelings, and behaviors of specific audiences. VA.RE.9.1.HSI: Establish relevant criteria in order to evaluate a work of art or collection of works.	**Technology and Engineering Standards:** 3.4.10.A2 Interpret how systems thinking applies logic and creativity with appropriate comprises in complex real-life problems. 3.4.10.C1 Apply the components of the technology design process. 3.3.10.C2 Analyze a prototype and/or create a model to test a design concept by making actual observations and necessary adjustments
Architectural Sculptures	3.5 weeks	How do form and function work together when designing architecture? How are spatial relationships used to draw, construct, and model real situations or solve problems? How does constructive	VA.CR.2.1.HSII: Through experimentation, practice, and persistence, demonstrate acquisition of skills and knowledge in a chosen art form. VA.CR.3.1.HSII: Engage in constructive critique with peers, then	**Technology and Engineering Standards:** 3.4.10.C1 Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.

		criticism and experimentation impact your revision and refinement of your work? How has architecture evolved over time? How can we use existing architectural elements to design an original architectural structure?	reflect on, re-engage, revise, and refine works of art and design in response to personal artistic vision.	3.4.10.C2 Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments. 3.4.10.E7 Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency. 3.4.10.D1 Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of a final product.
Fibonacci Object Drawings	3.5 weeks	What types of patterns or relationships are represented mathematically in nature? How can we determine the golden ratio and what is its use in art? How can recognition of pattern assist	VA.RE.7.2.HSI: Analyze how one's understanding of the world is affected by experiencing visual imagery. VA.CN.10.1.HSII: Utilize inquiry methods of observation, research, and experimentation to explore unfamiliar	**Math Common Core Standards:** CC.2.2.HS.C.1 Use the concept and notation of functions to interpret and apply them in terms of their context. CC.2.2.HS.C.2 Write functions

		artists in their observation and interpretations of visual imagery?	subjects through art making. VA.CR.1.2.HSI: Shape artistic investigations of an aspect of present-day life using a contemporary practice of art or design.	or sequences that model relationships between two quantities. A2.2.1.1.1 Analyze a set of data for the existence of a pattern and represent the pattern with a rule algebraically and/or graphically.
Islamic Tile Design	4 weeks	How has the Islamic culture and traditions influenced their art and architecture? How can we use geometry to create a complex, symmetrical design? How can we apply characteristics from Islamic art and culture to create an original tile design?	VaCr1.1.HS1: Use multiple approaches to begin creative endeavors VaCr3.1.HS1: Apply relevant criteria from traditional and contemporary cultural contexts to examine, reflect on, and plan revisions for works of art and design in progress VaCn11.1.HS1: Describe how knowledge of culture, traditions, and history may influence personal responses to art	**Math Common Core Standards:** G.CO.12: Make formal geometric constructions with a variety of tools and methods G.CO.13: Construct an equilateral triangle, square, and regular hexagon inscribed in a circle **American Council of the Teaching of Foreign Languages (ACTFL) Standards:** 2.1: Practices of Culture Students demonstrate an

		understanding of the relationship between the practices and perspectives of the culture studied. 2.2: Products of Culture Students demonstrate an understanding of the relationship between the products and perspectives of the culture studied.

Student Learning Maps, K-U-D Charts, and Unit Plans

Unit: Conservation and Art

Key Learning
Students will learn about the factors that influence use of natural resources and determine whether our current public policy encourages or discourages sustainability. Students will collaborate to brainstorm and strategize means of conserving natural resources. They will learn about a group of artists, designers, and architects who use their work to create awareness of environmental problems. Students will work in pairs to hypothesize and generate plans for a collaborative piece intended to play a role in solving an environmental problems.

Unit Essential Question
How can artists play a role in solving environmental problems in our society?

Concept	**Concept**	**Concept**
Students will be able to describe the effects of consumer demands on natural resources. Students will be able to	Students will be able to recognize personal responses to conservation. Students will be able to hypothesize and generate	Students will be able to interpret and analyze the impact of the work of artists, designers, and architects who create

explain how public policy influences sustainability.	plans for preventing, controlling, or reducing waste in our environment.	awareness for social change. Students will be able to choose materials and artistic processes that will elicit aesthetic and empathetic responses to environment issues.
Standards: Environment and Ecology 4.3.10A	**Standards:** Environment and Ecology 4.5.10A National Visual Art VA.RE.7.1.HSII VA.CR.1.1.HSIII	**Standards:** Environment and Ecology 4.5.10D National Visual Art VA.CR.1.2.HSII VA.PR.6.1.HSI
⇩	⇩	⇩
Lesson Essential Question How do consumer demands affect the use of natural resources?	**Lesson Essential Question** How can we prevent, control, or reduce waste in our environment?	**Lesson Essential Question** What materials and methods of artistic practices can be used in order to create art and design that affects social change?
⇩	⇩	⇩
Vocabulary Consumerism Natural Resources	**Vocabulary** Conservation Sustainability Waste management	**Vocabulary** Found objects Social change Stewardship Aurora Robson

KNOW What do students need to know in order to be able to do and understand?	**UNDERSTAND** What do students need to deeply understand? What is the big idea?	**DO** What do students need to be able to do by the end of the unit?
• Conservation • Sustainability • Natural resources • Social change • Stewardship • Public policies on conservation efforts • Found object	• How consumer demands affect natural resources • How public policy influences sustainability • Recognize their personal responses to the concept of	• Collaborate in order to hypothesize and generate plans for preventing, controlling, or reducing waste in the environment • Interpret and analyze the impact of artists, designers, and architects who create awareness for social change via their artistic processes and products

artwork • Artist- Aurora Robson	conservation • The importance of collaboration in problem solving • How artists and designers can create awareness and/or play a role in solving environmental problems	• Choose materials and artistic processes that will elicit aesthetic and empathetic responses to environmental issues • Create a piece of art that brings awareness to environmental problems in our society

Unit: Conservation Art **Grade Level:** 9-12
UEQ: How can artists play a role in solving environmental problems in our society?

LEQ: How do consumer demands affect the use of natural resources?
LEQ: How can we prevent, control, or reduce waste in our environment?
LEQ: What materials and methods of artistic practices can be used in order to create art and design that affects social change?
Lesson Description: Students will learn about the topic of conservation and sustainability of natural resources. Each student will be encouraged to form an opinion on the topic. They will look into public policies on conservation efforts and determine whether it encourages sustainability. They will work collaboratively to determine factors that contribute to the use of natural resources. Students will then be introduced to an artist named Aurora Robson who is a part of a larger artist foundation- Project Vortex. They will interpret and analyze how these artists have contributed to solving environmental problems in our society. The final project entails each student brainstorming, designing, and revising an artistic creation that elicits a response to conservation.
PA Academic Standards:
9.1.9B
Recognize, know, use and demonstrate a variety of appropriate art elements and principles to produce, review, and revise original works in the arts
9.1.9D
Communicate a unifying theme or point of view through the production of works in the arts
9.2.9 L
Identify, explain, and analyze common themes, forms and techniques from works in the arts
9.3.9 G
Compare and contrast critical positions or opinions about selected works in the arts and humanities
9.4.12B
Describe and analyze the effects that works in the arts have on groups, individuals and their culture
National Core Arts Standards:
VA.CR.1.1.HSIII

Visualize and hypothesize to generate plans for ideas and directions for creating art and design that can affect social change.

VA.CR.1.2.HSII
Choose from a range of materials and methods of traditional and contemporary artistic practices to plan works of art and design.
VA.RE.7.1.HSII
Recognize and describe personal aesthetic and empathetic responses to the natural world and constructed environments.
VA.PR.6.1.HSI
Analyze and describe impact that an exhibition or collection has on personal awareness of social, cultural, or political beliefs and understandings.

Environment and Ecology State Standards:
4.3.10A
Evaluate factors affecting the use of natural resources.
4.5.10A
Explain how public policy encourages or discourages the sustainable use of natural resources.
4.5.10D
Evaluate various methods of managing waste as related to economic, environmental, and technological factors.

Instructional Objectives:

- Students will be able to describe the effects of consumer demands on natural resources
- Students will be able to explain how public policy influences sustainability
- Students will be able to recognize personal responses to conservation
- Students will be able to hypothesize and generate plans for preventing, controlling, or reducing waste in the environment
- Students will be able to interpret and analyze the impact of the work of artists, designers, and architects who create awareness for social change
- Students will be able to choose materials and artistic processes that will elicit aesthetic and empathetic responses to environment issues

Set Up:

- Post Aurora Robson website and video links for student access
- Post website links to PA public policies and environmental organizations for student access
- LEQs and Word Wall
- Create online discussion post prompts
- Gather cutting and gluing tools (box cutters, Xactos, scissors, glue guns, rubber cement, etc.)

Learning Activities:

1. Defining and describing conservation- what do you know about it? What is your opinion or perspective on the use of natural resources?
2. Research conservation, sustainability, and public policies. Create a Google doc for notes and reflections on findings.
3. Watch Aurora Robson TedTalk video and add notes and reflections to Google doc.
4. Investigate Project Vortex artists and their work. Participate in online discussion post sharing one artist and their concept and process of working. Analyze how the artist has created awareness for social change. Comment on two peers' posts with personal reflections and comparison to other artists' work.
5. Collaborate in groups to brainstorm and generate ideas for reducing or preventing waste.
6. Whole group discussion on collaboration results.
7. Investigate Pennsylvania environmental organizations, brainstorm concepts for raising awareness for environmental problem, and create preliminary sketches for an artistic creation that reflects the chosen problem.
8. Select materials and/or processes that bring attention to the environmental problem. Post preliminary sketches and describe plan on the online discussion for peer feedback.
9. Design or create a final piece of art that elicits a response and brings awareness to an environmental problem.

Interdisciplinary Connections

- Science: Ecology and environment

Technology Integration

- TedTalk video
- Project Vortex website
- Artist and conservation research notes kept on Google docs
- Presentation about natural resources and public policy using technology (KeyNote, video, graphic organizer, etc.)
- Online discussion posts

Anticipatory Set

- Aurora Robson TedTalk video
- Independent research on conservation, sustainability, and public policies
- Collaborate with peers to hypothesize and generate plans for reducing waste

Modeling

- How to provide meaningful responses to peers in a discussion post
- How to find and cite academic sources

- How to carefully and intentionally select materials/media and techniques or processes that relate to project concept

Guided Practice

- Preliminary sketches for the final project

Formative Assessments

- Whole class discussion- how can we prevent or reduce waste?
- Google docs notes and reflections
- Online discussion posts
    - Sharing artists' work about conservation
    - Progress critique on art project

Modifications and Accommodations:

- Teacher reads aloud for student or student opts to utilize voice over on the iPad
- Option to orally submit any written responses
- Narrow down materials for student to select from 2 or 3 options
- One-on-one assistance with construction of project if necessary

Resources:

- Artist website- http://www.aurorarobson.com/cv--bio.html
- Project vortex website- http://www.projectvortex.org/about.html
- iPads
- apps- Google docs, KeyNote, etc.
- tools necessary for cutting and gluing materials
- PA public policies- https://ballotpedia.org/Environmental_policy_in_Pennsylvania http://conservationadvocate.org/conservation-and-preservation-easements-act/
- PA environmental organizations- http://www.eco-usa.net/orgs/pa.shtml
- National Geographic video "Why the ocean matters" http://video.nationalgeographic.com/video/why-ocean-matters
- Artists who are making art about conservation http://www.huffingtonpost.com/2014/07/15/environmental-art_n_5585288.html

Summative Assessment:

Discussion Rubric

Criteria	**7-10 points**	**4-6 points**	**0-3 points**

	Excellent Work	**Average Work**	**Needs Improvement**
Detail	The original post is 5+ descriptive sentences that accurately respond to each piece of the prompt.	The original post is 3-4 sentences that accurately respond to each piece of the prompt.	The original post is not descriptive and does not respond to each piece of the prompt.
Grammar	The post and response comments are grammatically correct.	There are 1-2 grammatical errors.	There are several grammatical errors.
Responses	There are two responses to two different peers that further the conversation with thoughtful questions or meaningful contributions.	There are two responses to two different peers that somewhat further the conversation, but could be more meaningful.	Only one response was posted, or the two responses were not meaningful contributions.
Citations	Outside sources are accurately cited using MLA style.	Outside sources are cited, but not using correct MLA style.	Outside sources were not cited.

Project Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Aesthetics	The overall piece utilizes the elements and principles of art to create an aesthetically pleasing appearance.	The overall piece somewhat utilizes the elements and principles of art in the aesthetic appearance.	The overall piece does not utilize the elements and principles of art in the aesthetic appearance.
Techniques/Processes	The piece utilized techniques and/or processes that bring attention to environmental issues.	The piece somewhat utilized techniques or processes that bring attention to environmental issues.	The piece did not utilize techniques or processes that bring attention to environmental issues.
Concept	The concept of the piece elicits a strong empathetic response to environmental issues.	The concept of the piece somewhat elicits an empathetic response to environmental issues.	There is not an apparent concept involving environmental issues.
Creativity	The concept, materials, and	The concept, materials, or	The concept, materials, and

	processes involved creative and original thinking.	processes involved some creative thinking.	processes were simple and unoriginal.
Craftsmanship	The overall piece demonstrates great attention to detail and neatness.	The overall piece demonstrates some attention to detail and neatness.	The overall piece is in need of attention to detail and neatness.
Reflection summary	The summary has four detailed paragraphs that reflect on the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary has three, moderately detailed paragraphs that reflect on some of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary is not descriptive or all encompassing of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Aesthetics	The overall piece utilizes the elements and principles of art to create an aesthetically pleasing appearance.	The overall piece somewhat utilizes the elements and principles of art in the aesthetic appearance.	The overall piece does not utilize the elements and principles of art in the aesthetic appearance.
Techniques/Processes	The piece utilized techniques and/or processes that bring attention to environmental issues.	The piece somewhat utilized techniques or processes that bring attention to environmental issues.	The piece did not utilize techniques or processes that bring attention to environmental issues.
Concept	The concept of the piece elicits a strong empathetic response to environmental issues.	The concept of the piece somewhat elicits an empathetic response to environmental issues.	There is not an apparent concept involving environmental issues.
Creativity	The concept, materials, and processes involved creative and original thinking.	The concept, materials, or processes involved some creative thinking.	The concept, materials, and processes were simple and unoriginal.
Craftsmanship	The overall piece	The overall piece	The overall piece is

	demonstrates great attention to detail and neatness.	demonstrates some attention to detail and neatness.	in need of attention to detail and neatness.
Reflection summary	The summary has four detailed paragraphs that reflect on the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary has three, moderately detailed paragraphs that reflect on some of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary is not descriptive or all encompassing of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.

Unit**:** Logo Designs

Key Learning
Students will be exposed to various brand logos in order to identify the elements and principles of design that are utilized and analyze how designers convey meaning and communicate messages using visual imagery. Each student will need to brainstorm and generate a company with a specific service or product for which they will create a brand identity with their own original logo design. Students will experiment with combinations of typefaces and color palettes, revise their prototypes, and create a final logo design using technology.

Unit Essential Question
How can an image influence ideas, feelings, or behaviors from specific audiences?

Concept	**Concept**	**Concept**
Students will be able to identify the elements and principles of design that are used in brand logos. Students will be able to describe how the elements and principles are used in logos to convey meaning.	Students will be able to analyze the characteristics that artists and designers use to create designs that effectively communicate a message. Students will be able to brainstorm, visualize, and generate thumbnail sketches of various logo designs.	Students will be able to critique and revise their thumbnails and prototypes by using their knowledge of the elements and principles of design. Students will be able to use technology in order to create an original logo design that meets criteria for conveying meaning and effectively communicating a message.

Standards: Technology 3.4.10.C1 National Visual Art VaCr1.1.HS1	**Standards:** Technology 3.4.10.A2 National Visual Art VA.RE.9.1.HSI	**Standards:** Technology 3.3.10.C2 National Visual Art VA.RE.7.2.HSII
Lesson Essential Question How are the elements of art and principles of design used to convey meaning in graphic design?	**Lesson Essential Question** How do artists and designers create works of design that effectively communicate?	**Lesson Essential Question** How can we use technology to create an original logo design for a company?
Vocabulary Unity Emphasis Color Contrast	**Vocabulary** Visual literacy Palette Color Theory Typeface Thumbnail sketches	**Vocabulary** Brand identity Graphic design Typography

KNOW What do students need to know in order to be able to do and understand?	**UNDERSTAND** What do students need to deeply understand? What is the big idea?	**DO** What do students need to be able to do by the end of the unit?
• Elements and principles of art and design • Visual literacy • Color theory • Graphic design • Typography • Thumbnail sketches	• How color theory and typeface influence the meaning and message of a logo • The importance of unity, emphasis, color, and contrast in designing a logo • How to formulate a brand identity using visual imagery • Technology processes for designing a logo	• Analyze how other designers have created logos that effectively communicate a message • Interpret how complex real-life problems require both logic and creativity • Brainstorm and generate thumbnail sketches for logo design ideas that use various typefaces and color palettes • Provide constructive criticism to their peers using a set of pre-determined criteria • Apply technology design

	• The importance of constructive criticism in the process of revising and refining an end product	processes to create the final logo design • Create an original logo design that effectively communicates a message to its intended audience

Unit: Logo Designs **Grade Level:** 9-12

UEQ: How can an image influence ideas, feelings, or behaviors from specific audiences?

LEQ: How are the elements of art and principles of design used to convey meaning in graphic design?

LEQ: How do artists and designers create works of design that effectively communicate?

LEQ: How can we use technology to create an original logo design for a company?

Lesson Description: Students will be exposed to various brand logos in order to identify the elements and principles of design that are utilized and analyze how designers convey meaning and communicate messages using visual imagery. Each student will need to brainstorm and generate a company with a specific service or product for which they will create a brand identity with their own original logo design. They will learn and apply graphic design terminology and processes. Throughout the process, students will experiment with combinations of typefaces and color palettes, revise their prototypes, and create a final logo design using an iPad application.

PA Academic Standards:

9.1.9B

Recognize, know, use, and demonstrate a variety of appropriate arts elements and principles to produce, review, and revise original works in the arts

9.1.9J

Incorporate specific uses of traditional and contemporary technologies within the design for producing, performing, and exhibiting works in the arts

9.3.9A

Know and use the critical process of the examination of works in the arts and humanities

9.3.9B

Analyze and interpret specific characteristics of works in the arts within each art form

National Core Arts Standards:

VaCr1.1.HS1

Use multiple approaches to begin creative endeavors

VA.RE.7.2.HSII

Evaluate the effectiveness of an image or images to influence ideas, feelings, and behaviors of specific audiences.

VA.RE.9.1.HSI

Establish relevant criteria in order to evaluate a work of art or collection of works.

Technology and Engineering State Standards:

3.4.10.A2

Interpret how systems thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.10.C1
Apply the components of the technology design process.
3.3.10.C2
Analyze a prototype and/or create a model to test a design concept by making actual observations and necessary adjustments

Instructional Objectives:

- Students will be able to identify the elements and principles of design that are used in brand logos.
- Students will be able to describe how the elements and principles are used in logos to convey meaning.
- Students will be able to analyze the characteristics that artists and designers use to create designs that effectively communicate a message.
- Students will be able to brainstorm, visualize, and generate thumbnail sketches of various logo designs.
- Students will be able to critique and revise their thumbnails and prototypes by using their knowledge of the elements and principles of design.
- Students will be able to use technology in order to create an original logo design that meets criteria for conveying meaning and effectively communicating a message.

Set Up:

- Have students download 'Makr' and 'Assembly' apps on their iPads
- Post links to resources and YouTube video for student access

Learning Activities:

1. Whole class discussion- What makes a good logo? Think-pair-share to create a list and then share with the whole class.
2. Investigate various famous logo designs online. List common characteristics throughout the designs.
3. Select two favorite logo designs. Analyze how the designer utilized the elements and principles of art. Describe how the elements and principles convey meaning.
4. Brainstorm and generate an idea for an imaginary company with a specific service or product and a specific audience.
5. Create a visual chart that defines and illustrates graphic design terminology.
6. Watch the logo design process YouTube video and summarize important steps to the process.
7. Discuss brand identity, typography, and color palettes in graphic design.
8. Create a digital mood board of logo inspirations.
9. Brainstorm ideas and generate thumbnail sketches and illustrations of visual imagery and typefaces for the company logo.
10. Participate in a progress critique with peers in order to revise and refine thumbnail sketches.

11. Create various color palettes that would create unity in the logo design.
12. Create a final logo design that conveys a message for its intended audience using the Makr or Assembly app on the iPad.

Interdisciplinary Connections

- Technology and Design

Technology Integration

- Using an iPad application to create a final product

Anticipatory Set

- 'What company is this?' using Logo game cards
- Whole class discussion on what makes a good logo- create a T-chart of good vs. bad logo elements
- Watch YouTube video of a designer explaining his logo process

Modeling

- Model good vs. bad typeface choices
- Model selection of color palette
- Demonstrate how to use the logo application on the iPad

Guided Practice

- Create thumbnail sketches and prototypes of logo designs that utilize various typefaces, icons, and color palettes

Formative Assessments

- Thumbnails and prototypes- are they meeting criteria?

Modifications and Accommodations:

- Teacher reads aloud for student or student opts to utilize voice over on the iPad
- Option to orally submit any written responses
- One-on-one assistance with using the logo app if necessary
- Narrow down student options for typeface to 3 or 4

Resources:

- iPads
- Makr and Assembly apps
- Graphic design terminology https://designschool.canva.com/blog/graphic-design-terms/
- iPad art room lesson plans http://www.ipadartroom.com/shaping-symbols-constructing-logos-with-apps/

- Logo design galleries
  http://logodesignerblog.com/top-best-10-logo-design-inspiration-galleries/
  http://designspiration.net/search/saves/page/2/?q=logo
- Logo design process video
  https://www.youtube.com/watch?v=dPpZxq0fJRo
- Psychology of color
  http://www.sprucerd.com/blog/color-psychology/
- Logo design trends
  https://www.entrepreneur.com/article/282773

Summative Assessment:

Discussion Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Detail	The original post is 5+ descriptive sentences that accurately respond to each piece of the prompt.	The original post is 3-4 sentences that accurately respond to each piece of the prompt.	The original post is not descriptive and does not respond to each piece of the prompt.
Grammar	The post and response comments are grammatically correct.	There are 1-2 grammatical errors.	There are several grammatical errors.
Responses	There are two responses to two different peers that further the conversation with thoughtful questions or meaningful contributions.	There are two responses to two different peers that somewhat further the conversation, but could be more meaningful.	Only one response was posted, or the two responses were not meaningful contributions.
Citations	Outside sources are accurately cited using MLA style.	Outside sources are cited, but not using correct MLA style.	Outside sources were not cited.

Project Rubric

Criteria	**0-3 points**	**4-6 points**	**7-10 points**
Image	The selected logo image does not communicate the intended message.	The selected logo image somewhat communicates the intended message.	The selected logo image effectively communicates the intended message.
Text	The selected	The selected	The selected

	typeface does not communicate the intended message and does not read legibly.	typeface somewhat communicates the intended message.	typeface complements the image, reads legibly, and effectively communicates the intended message.
Color palette	The chosen color palette of the logo does not create a sense of unity.	The chosen color palette of the logo somewhat creates a sense of unity with the image and typeface.	The chosen color palette of the logo creates a sense of unity with the image and typeface.
Creativity	The overall logo design does not show creative thinking.	The overall logo design somewhat shows creative thinking.	The overall logo design shows originality and creative thinking.
Brand identity	The overall logo design elements do not create a brand identify for the company.	The overall logo design elements somewhat create a brand identity for the company.	The overall logo design elements create a strong brand identity for the company.

Unit: Architectural Sculptures

Key Learning
Students will learn a brief overview of the history of architecture design in order to understand how the structures have evolved over time. Students will learn about the issues and problems that need to be solved when designing and constructing architectural structures. Each student will research a variety of architectural styles in order to brainstorm and generate prototypes of an original structure using technology. Students will use peer collaboration and constructive criticism to revise and refine their final product, which will be fabricated using student-selected materials.

Unit Essential Question
What are necessary components for designing and constructing structurally sound and aesthetically pleasing architectural structure?

Concept	**Concept**	**Concept**
Students will be able to identify and describe how form and function work together in architectural design.	Students will be able to utilize spatial relationships in the designing and constructing of their architectural structures.	Students will be able to describe how architecture has evolved over time. Students will be able to apply architectural design

	Students will be able to apply constructive criticism to their revision and refinement of their blueprints and prototypes.	styles to create an original architectural structure.
Standards: Technology and Engineering 3.4.10.E7	**Standards:** Technology and Engineering 3.4.10.C2 3.4.10.D1 National Visual Art VA.CR.3.1.HSII	**Standards:** Technology and Engineering 3.4.10.C1 National Visual Art VA.CR.2.1.HSII
Lesson Essential Question How do form and function work together when designing architecture?	**Lesson Essential Question** How are spatial relationships used to draw, construct, and model real situations or solve problems? How does constructive criticism and experimentation impact your revision and refinement of your work?	**Lesson Essential Question** How has architecture evolved over time? How can we use existing architectural styles to design an original architectural structure?
Vocabulary Form Space Function Architecture	**Vocabulary** Prototype Maquette Fabricate Efficiency Convenience	**Vocabulary** Ancient Egypt Classical Neoclassical Byzantine Gothic Renaissance Baroque Neoclassicism Art Deco Modernist

KNOW What do students need to know in order to be able to do and understand?	**UNDERSTAND** What do students need to deeply understand? What is the big idea?	**DO** What do students need to be able to do by the end of the unit?
• Architecture • Form	• The difference between form and	• Compare and contrast two different architectural styles

• Space • Function • Prototype • Maquette • Fabricate • Efficiency • Convenience • Architectural styles: Ancient Egypt Classical Neoclassical Byzantine Gothic Renaissance Baroque Neoclassicism Art Deco Modernist	function in architecture • How architectural styles have evolved over history • How spatial relationships are used to draw, construct, and model real situations and complex real-life problems • The importance of experimentation and revision in creating an efficient end product	• Formulate architectural blueprint drawings using graph paper and drawing tools • Render a three-dimensional prototype of blueprints using technology • Construct a maquette of the prototype • Analyze and refine prototype and maquette using factors such as style, convenience, and efficiency • Engage in constructive critique with peers in order to further refine the design and personal artistic vision • Fabricate an architectural structure that utilizes stylistic features from two or more architecture styles

Unit: Architecture **Grade Level:** 9-12
UEQ: What are necessary components for designing and constructing structurally sound and aesthetically pleasing architectural structures?

LEQ: How do form and function work together when designing architecture?
LEQ: How are spatial relationships used to draw, construct, and model real situations or solve problems?
LEQ: How does constructive criticism and experimentation impact your revision and refinement of your work?
LEQ: How has architecture evolved over time?
LEQ: How can we use existing architectural styles to design an original architectural structure?
Lesson Description: Students will learn a brief overview of the history of architecture design in order to understand how the structures have evolved over time. Each student will create his or her own digital timeline/overview of the history of architecture. Students will learn about the issues and problems that need to be solved when designing and constructing architectural structures. Each student will research a variety of architectural styles in order to brainstorm and generate blueprints and prototypes of an original structure using technology. Students will use peer collaboration and constructive criticism to revise and refine their final product, which will be fabricated using student-selected materials.
PA Academic Standards:
9.1.9B

Recognize, know, use and demonstrate a variety of appropriate arts elements and principles to produce, review, and revise original works in the arts
9.1.9D
Demonstrate knowledge of at least two styles within each art form through performance or exhibition of unique works
9.1.9H
Demonstrate and maintain materials, equipment, and tools safely at work and performance spaces
9.2.9C
Relate works in the arts to varying styles and genre to the periods in which they were created
9.3.9A
Know and use the critical process of the examination of works in the arts and humanities

National Core Arts Standards:

VA.CR.2.1.HSII
Through experimentation, practice, and persistence, demonstrate acquisition of skills and knowledge in a chosen art form.
VA.CR.3.1.HSII
Engage in constructive critique with peers, then reflect on, re-engage, revise, and refine works of art and design in response to personal artistic vision.

Technology and Engineering State Standards:

3.4.10.C1
Recognize that technological development has been evolutionary, the result of a series of refinements to a basic invention.
3.4.10.C2
Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.
3.4.10.E7
Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.
3.4.10.D1
Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of a final product.

Instructional Objectives:

- Students will be able to identify and describe how form and function work together in architectural design
- Students will be able to utilize spatial relationships in the designing and constructing of their architectural structures
- Students will be able to apply constructive criticism to their revision and refinement of their blueprints and prototypes
- Students will be able to describe how architecture has evolved over time
- Students will be able to apply architectural design styles to create an original architectural structure

Set Up:

- Download Virtual Tour app on iPads
- Download SketchUp software on desktops
- Word Wall and EQs
- Create online discussion prompts
- Collect pieces of scrap cardboard and mat board
- Post links to architecture websites for student access

Learning Activities:

1. Explore famous buildings using the Virtual Tour app
2. Create a digital timeline/overview of the evolution of architectural styles
3. Compare and contrast two different architecture styles
4. Research architectural structures from 2-3 specific styles for reference imagery
5. Discuss areas of concern and problems to be solved when designing architecture
6. Formulate blueprints of 4 different angles for an architectural structure based on selected styles
7. Design 2-3 prototypes using SketchUp or another design software
8. Participate in an online progress critique discussion by analyzing the form and function of peers' designs
9. Construct a maquette of the revised design using cardboard and/or mat board
10. Create a final architectural structure using selected materials

Interdisciplinary Connections

- Technology
- Engineering

Technology Integration

- Virtual Tour app on the iPad to see famous architectural buildings
- Creating a digital timeline of the history of architecture
- Researching architectural styles
- SketchUp software for formulating architectural plans

Anticipatory Set

- Presentation on brief architectural history
- Virtual Tour exploration of famous buildings
- Exploring Frank Lloyd Wright blueprints, buildings, and influences

Modeling

- Demonstrate how to create blueprints using spatial relationships
- Demonstrate how to use and navigate the SketchUp software
- Provide examples of form and function
- Model meaningful constructive criticism

- Demonstrate proper use of cutting tools

Guided Practice

- Blueprints on graph paper
- Prototypes on SketchUp
- Maquette of final product

Formative Assessments

- Blueprint drawings- check for spatial relationships, form and function
- Prototypes on SketchUp (or other chosen software)- check for originality
- Maquette- check for accurate measurements and application of constructive criticism

Modifications and Accommodations:

- Teacher reads aloud for student or student opts to utilize voice over on the iPad
- Option to orally submit any written responses
- Narrow down architectural style options to 3-4
- Modify assignment to require fewer blueprints and prototypes
- One-on-one assistance with technology and/or construction of product if necessary
- Do not deduct points for mathematical errors

Resources:

- iPads and desktop computers
- https://www.thoughtco.com/teaching-and-learning-about-architecture-178436
- https://www.theartofed.com/2014/11/11/10-architectural-marvels-to-inspire-your-teaching/
- Frank Lloyd Wright- http://franklloydwright.org/illuminating-details-frank-lloyd-wrights-guggenheim-blueprints/
- Virtual Tour app
- SketchUp software
- Graph paper, rulers, T-squares, protractors, compasses
- Cardboard and mat board for maquettes
- Box cutters, Xactos, cutting mats, glue guns and sticks

Summative Assessment:

Discussion Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Detail	The original post is	The original post is	The original post is

	5+ descriptive sentences that accurately respond to each piece of the prompt.	3-4 sentences that accurately respond to each piece of the prompt.	not descriptive and does not respond to each piece of the prompt.
Grammar	The post and response comments are grammatically correct.	There are 1-2 grammatical errors.	There are several grammatical errors.
Responses	There are two responses to two different peers that further the conversation with thoughtful questions or meaningful contributions.	There are two responses to two different peers that somewhat further the conversation, but could be more meaningful.	Only one response was posted, or the two responses were not meaningful contributions.
Citations	Outside sources are accurately cited using MLA style.	Outside sources are cited, but not using correct MLA style.	Outside sources were not cited.

Project Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Prototypes and Maquette	The prototypes and maquette show strong evidence of experimentation, practice, and acquisition of skills.	The prototypes and maquette show some evidence of experimentation, practice, and aquistion of skills.	The prototypes and maquette do not show evidence of experimentation, practice, and acquisition of skills.
Style	The final product illustrates design or structural elements from two or more architectural styles.	The final product illustrates a design or structural element from one architectural style.	The final product does not illustrate a design or structural element from an architectural style.
Creativity	The overall product shows a variety of creative choices in form and function.	The overall product shows some creative choices in form and function.	The overall product is simple or unoriginal.
Craftsmanship	The overall product is structurally sound, clean, and measured to scale.	The overall product has a few issues with the structure, neatness, or	The overall product has several issues with the structure, neatness, or

		measurements.	measurements.
Constructive criticism	The final product shows strong evidence of revision and refinement from the original blueprints.	The final product shows some evidence of revision and refinement from the original blueprints.	The final product does not show evidence of revision or refinement from the original blueprints.
Reflection summary	The summary has four detailed paragraphs that reflect on the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary has three, moderately detailed paragraphs that reflect on some of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary is not descriptive or all encompassing of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.

Unit**:** Fibonacci Drawings

Key Learning
Students will be introduced to the Fibonacci sequence and will learn how to identify and solve Fibonacci spirals. They will be introduced to traditional artists whose work utilized the Fibonacci spiral in the composition choices. Students will also learn how the Fibonacci sequence influenced artists' knowledge of scale and proportions. Each student will create a piece of art that renders an object from nature that illustrates the Fibonacci spiral.

Unit Essential Question
How do sequential patterns and ratios influence artistic choices?

Concept	**Concept**	**Concept**
Students will be able to identify and describe patterns and relationships amongst objects in nature. Students will be able to identify and solve the function of the Fibonacci sequence. Students will be able to use the function of the Fibonacci sequence to	Students will be able to use the concept of the Golden spiral to determine the Golden ratio. Students will be able to describe the use of the golden ratio in art and design.	Students will be able to analyze the relationship between art and mathematical functions. Students will be able to apply the function of the Fibonacci sequence to create an original piece of art.

create a Golden spiral.		
Standards: Math Common Core A2.2.1.1.1 CC.2.2.HS.C.3	**Standards:** Math Common Core CC.2.2.HS.C.1 National Visual Art VA.CN.10.1.HSII	**Standards:** National Visual Art VA.RE.7.2.HSI VA.CR.1.2.HSII
Lesson Essential Question What types of patterns or relationships are represented mathematically in nature?	**Lesson Essential Question** How can we determine the golden ratio and what is its use in art?	**Lesson Essential Question** How can recognition of pattern assist artists in their observation and interpretations of visual imagery? How does knowing the contexts of histories and traditions of art forms help us to create works of art?
Vocabulary Pattern Fibonacci sequence Fibonacci spiral	**Vocabulary** Golden ratio Phi Circumference Scale	**Vocabulary** Divine Proportion Leonardo da Vinci Composition Rule of thirds

KNOW What do students need to know in order to be able to do and understand?	**UNDERSTAND** What do students need to deeply understand? What is the big idea?	**DO** What do students need to be able to do by the end of the unit?
• Pattern • Fibonacci sequence • Fibonacci spiral • Golden ratio • Phi • Circumference • Scale • Divine Proportion • Leonardo da Vinci • Composition • Rule of thirds	• How the golden ratio is determined • How the golden ratio is utilized in art • The relationship between the Fibonacci sequence and artistic choices • The importance of knowing the contexts of histories and traditions of art	• Identify and describe patterns in objects found in nature • Recognize the pattern in the Fibonacci sequence • Formulate the golden spiral using the Fibonacci sequence • Identify the golden ratio or spiral in famous paintings • Utilize the Fibonacci sequence to create an original piece of artwork

	forms	

Unit: Fibonacci Art **Grade Level:** 9-12
UEQ: How do sequential patterns and ratios influence artistic choices?

LEQ: What types of patterns or relationships are represented mathematically in nature?
LEQ: How can we determine the golden ratio and what is its use in art?
LEQ: How can recognition of pattern assist artists in their observation and interpretations of visual imagery?
LEQ: How does knowing the contexts of histories and traditions of art forms help us to create works of art?
Lesson Description: Students will be introduced to the Fibonacci sequence and will learn how to identify and solve Fibonacci spirals. They will be introduced to traditional artists such as Leonardo DaVinci whose work utilized the Fibonacci spiral in the composition choices. Students will also learn how the Fibonacci sequence influenced artists' knowledge of scale and proportions. Each student will create a piece of art that renders an object from nature (i.e. pine cone, sunflower, seashell, etc.) that illustrates the Fibonacci spiral.
PA Academic Standards:
9.1.9A
Know and use the elements and principles of each art form to create works in the arts and humanities
9.2.9K
Identify, explain, and analyze traditions as they relate to works in the arts
9.3.9D
Evaluate works in the arts and humanities using a complex vocabulary of critical response
National Core Arts Standards:
VA.RE.7.2.HSI
Analyze how one's understanding of the world is affected by experiencing visual imagery.
VA.CN.10.1.HSII
Utilize inquiry methods of observation, research, and experimentation to explore unfamiliar subjects through art making.
VA.CR.1.2.HSI
Shape artistic investigations of an aspect of present-day life using a contemporary practice of art or design.
Math Common Core Standards:
CC.2.2.HS.C.1
Use the concept and notation of functions to interpret and apply them in terms of their context.

CC.2.2.HS.C.2
Write functions or sequences that model relationships between two quantities.

A2.2.1.1.1
Analyze a set of data for the existence of a pattern and represent the pattern with a rule

algebraically and/or graphically.

Instructional Objectives:

- Students will be able to identify and describe patterns and relationships amongst objects in nature
- Students will be able to identify and solve the function of the Fibonacci sequence
- Students will be able to use the function of the Fibonacci sequence to create a Golden spiral
- Students will be able to use the concept of the Golden spiral to determine the Golden ratio
- Students will be able to describe the use of the Golden ratio in art and design
- Students will be able to analyze the relationship between art and mathematical functions
- Students will be able to apply the function of the Fibonacci sequence to create an original piece of art

Set Up:

- Post links to websites for student access
- Word wall and LEQs
- Download Nearpod app
- Create slideshow of images of objects in nature that depict the golden spiral

Learning Activities:

1. Independent reading on the golden ratio with follow-up discussion.
2. Whole class participation in Nearpod presentation- Fibonacci in nature.
3. Demonstration on the Fibonacci sequence and practice exercises.
4. Watch Divine Proportion video. Think-pair-share presentation on an artist whose work utilized the golden ratio.
5. Whole class discussion- describe the relationship between mathematical functions and art.
6. Practice drawing the golden spiral using the Fibonacci sequence on graph paper.
7. Select an object from nature that depicts the golden spiral and create 4-5 thumbnail sketches of various composition choices.
8. Peer critique thumbnail sketches to select the best composition choice.
9. Create a piece of art using the Fibonacci sequence that accurately depicts the golden spiral.

Interdisciplinary Connections

- Math- Geometry/Algebra

Technology Integration

- Nearpod presentation- Fibonacci in nature

Anticipatory Set

- Slideshow of objects in nature that have the golden spiral
  - Students asked to identify common patterns that they observe
- Read the Live Science webpage, "What is the Golden Ratio?"
- Nearpod presentation
- Watch da Vinci "Divine Proportion" video on golden number website
- Students work in pairs to present to the class an artist who utilized the golden ratio

Modeling

- Teach and demonstrate the Fibonacci sequence
- Model how to use to the golden ratio for composition choices
- Model how to use the pattern of the Fibonacci sequence to draw an object's golden spiral to scale with accurate proportions

Guided Practice

- Complete practice exercises of the Fibonacci sequence
- Practice creating the golden spiral on graph paper
- Create thumbnail sketches of the object

Formative Assessments

- Practice exercises- check for correct sequential pattern
- Graph paper spiral drawings- check for correct math
- Thumbnail sketches- check for balanced composition choice

Modifications and Accommodations:

- Teacher reads aloud for student or student opts to utilize voice over on the iPad
- Option to orally submit any written responses
- One-on-one assistance with math/sequences

Resources:

- iPads
- Nearpod app
- Graph paper and rulers
- https://www.livescience.com/37704-phi-golden-ratio.html
- https://www.goldennumber.net/art-composition-design/
- http://www.markmitchellpaintings.com/blog/the-fibonacci-sequence-in-artistic-composition/

Summative Assessment:

Discussion Rubric

Criteria	**7-10 points**	**4-6 points**	**0-3 points**

	Excellent Work	**Average Work**	**Needs Improvement**
Detail	The original post is 5+ descriptive sentences that accurately respond to each piece of the prompt.	The original post is 3-4 sentences that accurately respond to each piece of the prompt.	The original post is not descriptive and does not respond to each piece of the prompt.
Grammar	The post and response comments are grammatically correct.	There are 1-2 grammatical errors.	There are several grammatical errors.
Responses	There are two responses to two different peers that further the conversation with thoughtful questions or meaningful contributions.	There are two responses to two different peers that somewhat further the conversation, but could be more meaningful.	Only one response was posted, or the two responses were not meaningful contributions.
Citations	Outside sources are accurately cited using MLA style.	Outside sources are cited, but not using correct MLA style.	Outside sources were not cited.

Project Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Scale	The chosen object is rendered to scale.	The chosen object is mostly rendered to scale.	The chosen object is not rendered to scale.
Proportion	The chosen object is rendered with accurate proportions.	The chosen object is mostly rendered with accurate proportions.	The chosen object is not rendered with accurate proportions.
Spiral	The pattern of the golden spiral is illustrated in the piece.	The golden spiral is illustrated in the piece, but the pattern is somewhat inaccurate.	The golden spiral pattern is not apparent or completely inaccurate.
Composition	The composition shows great understanding of balance and focal	The composition shows some understanding of balance and focal	The composition is not balanced and there is not an apparent focal point.

	point.	point.	
Craftsmanship	The piece is completed with great attention to detail and the media is applied well.	The piece is mostly completed with attention to detail and media is applied moderately well.	The piece is in need of attention to detail and neatness.
Reflection summary	The summary has four detailed paragraphs that reflect on the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary has three, moderately detailed paragraphs that reflect on some of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	The summary is not descriptive or all encompassing of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.

Unit: Islamic Designs

Key Learning
Students will learn about famous Islamic art and architecture in a historical context. We will discuss the influential aspects of Islamic design and the tradition of some of the culture's artwork, with an emphasis on geometry. Students will use graph paper and tools to experiment with constructing and combining polygons. Each student will then create their own Islamic tile design that incorporates a geometric, symmetrical pattern that is inspired by characteristics found in Islamic art.

Unit Essential Question
How does knowledge of culture and traditions influence understanding of artistic choices?

Concept	**Concept**	**Concept**
Students will be able to recognize ways that works of art from the Islamic world utilize geometric forms and relationships.	Students will be able to use a compass and straightedge to construct geometric polygons. Students will be able to create a symmetrical geometric tile design that is influenced by Islamic art and culture.	Students will be able to apply a specific color scheme to their designs that demonstrates understanding of the elements and principles of art. Students will be able to explain design choices and connections to the Islamic culture in a written statement.

Standards: National Visual Art VA.CR.3.1.HS1 ACTFL 2.1	**Standards:** National Visual Art VA.CR.1.1.HS1 Math Common Core G.CO.12 G.CO. 13	**Standards:** National Visual Art VA.CN.11.1.HS1 ACTFL 2.2 4.2
⇩	⇩	⇩
Lesson Essential Question How has the Islamic culture and traditions influenced their art and architecture?	**Lesson Essential Question** How can we use geometry to create a complex, symmetrical design?	**Lesson Essential Question** How can we apply characteristics from Islamic art and culture to create an original tile design?
⇩	⇩	⇩
Vocabulary Symmetry Geometric Calligraphy	**Vocabulary** Compass Repetition Polygons Textile Tessellation	**Vocabulary** Islam Culture Mathematicians Philosophy

KNOW What do students need to know in order to be able to do and understand?	**UNDERSTAND** What do students need to deeply understand? What is the big idea?	**DO** What do students need to be able to do by the end of the unit?
• Symmetry • Geometric shapes • Repetition • Polygons • Compass • Islam • Calligraphy • Textiles • Tessellations • Mathematicians • Philosophy • Culture	• How the Islamic culture, history, and traditions influenced their art, design, and architecture • The common characteristics found in Islamic art and design • How geometry is utilized in Islamic design • The relationship between the practices and perspectives of the	• Construct an equilateral triangle, square, and hexagon inside of a circle • Construct combinations of polygons using graph paper, compasses, straight edges, and geometric formulas • Create an original tile design that utilizes common characteristics of Islamic art and design • Apply knowledge of elements of art and design to design and color scheme • Explain design choices and influences from the Islamic

	Islam culture • The relationship between the products and perspectives of the Islam culture	culture

Unit: Islamic Tile Design **Grade Level:** 9-12
UEQ: How does knowledge of culture and traditions influence understanding of artistic choices?
LEQ: How has the Islamic culture and traditions influenced their art and architecture?
LEQ: How can we use geometry to create a complex, symmetrical design?
LEQ: How can we apply characteristics from Islamic art and culture to create an original tile design?
Lesson Description: At the beginning of this unit, the art and Spanish students will be introduced to a brief historical, cultural background of Islamic art. We will discuss the influential aspects of Islamic design and the tradition of some of the culture's artwork, with an emphasis on geometry. Students will then create their own Islamic tile design that incorporates a geometric, symmetrical pattern that is inspired by characteristics found in Islamic art. Once the overall design is drawn, it will be completed using a specific color scheme such as complementary, analogous, or warm/cool colors. In the final product, students will be assessed on complexity and accuracy of the utilization of geometry in their designs as well as application of the applied color scheme. In addition to final product, students will be assessed on their written self-reflections.
PA Academic Standards:
9.1.9 B: Recognize, know, use, and demonstrate a variety of appropriate arts elements and principles to produce, review, and revise original works in the arts
9.1.9 C: Identify and use comprehensive vocabulary within each of the arts forms
9.2.9 E: Analyze how historical events and culture impact forms, techniques, and purposes of works in the arts
9.2.9 F: Know and apply appropriate vocabulary used between social studies and the arts and humanities
9.3.9 B: Analyze and interpret specific characteristics of works in the arts within each art form
National Core Arts Standards:
VaCr1.1.HS1: Use multiple approaches to begin creative endeavors
VaCr3.1.HS1: Apply relevant criteria from traditional and contemporary cultural contexts to examine, reflect on, and plan revisions for works of art and design in progress
VaCn11.1.HS1: Describe how knowledge of culture, traditions, and history may influence personal responses to art
Math Common Core State Standards:
G.CO.12: Make formal geometric constructions with a variety of tools and methods
G.CO.13: Construct an equilateral triangle, square, and regular hexagon inscribed in a circle
American Council of the Teaching of Foreign Languages (ACTFL) standards:

2.1: Practices of Culture
Students demonstrate an understanding of the relationship between the practices and perspectives of the culture studied.

2.2: Products of Culture
Students demonstrate an understanding of the relationship between the products and perspectives of the culture studied.

Instructional Objectives:

- Students will be able to recognize ways works of art from the Islamic world utilize geometric forms and relationships
- Students will be able to use a compass and straightedge to construct polygons
- Students will be able to create a symmetrical geometric tile design that is influenced by Islamic art and culture
- Students will be able to apply a specific color scheme to their designs that demonstrates understanding of the arts elements and principles
- Students will be able to explain their design choices and connections to the Islamic culture in a written statement

Set Up:

- Copies of Metropolitan of Art Museum reading about Islamic art and culture
- Copies of project packet with vocabulary, reading comprehension questions, preliminary sketching and brainstorming, and rubric
- Post links to websites with examples of Islamic art and design and videos about Islamic art and architecture
- LEQs and Word Wall
- Cut white drawing paper 12”x12”
- Cut colored railroad board 13”x13”
- Gather graph paper, protractors, and compasses

Learning Activities:

1. Reading and small group discussion on “Geometric Design in Islamic Art” packet from the Metropolitan Museum of Art- What influenced Islamic art?
2. Comparing and contrasting characteristics of Islamic art, architecture, and textiles
3. Presentation on Islamic history and culture with a virtual tour of famous Islamic architecture in Spain
4. Whole group discussion on how art from the Islamic world utilized geometric forms and relationships- How is geometry a part of the Islamic culture and tradition?
5. Identifying geometric polygons and constructions in Islamic designs
6. Constructing symmetrical designs using geometric constructions
7. Brainstorming, designing, revising, and finalizing an original Islamic tile design

Interdisciplinary Connections

- Language and culture
- Math/Geometry

Technology Integration

- Online videos about Islamic art and explanations of geometric designs
- Virtual tour of famous Islamic architectural structures
- Online discussion board for project progress critique

Anticipatory Set

- Independent reading and writing response questions followed with group discussion
- Defining/illustrating vocabulary terms
- Video- Islamic design & geometry
- Identify polygons in artwork and practice/experiment using graph paper, protractors, rulers, and compasses

Modeling

- Utilizing a straightedge and compass to draw polygons on graph paper
- How to provide meaningful constructive criticism using a set of predetermined criteria
- Creating a geometric pattern using combinations of polygons
- How to shade properly with colored pencils

Guided Practice

- Practicing drawing geometric shapes and designs on graph paper using rulers, protractors, and compasses

Formative Assessments

- Preliminary sketches of geometric and symmetrical patterns on graph paper
- Ticket-out-the door: listing common characteristics of Islamic art and design
- Progress critique- using criteria to provide constructive criticism

Modifications and Accommodations:

- Teacher reads aloud the reading packet and question prompts or student opts to use voice over on the iPad
- Help student select a simplified geometric pattern for the student and allow student to use shape tracers
- Choose a 2 color complementary color scheme (give them the option of which set)

- Option to orally submit responses to self-reflection prompts

Resources:

- Project packet
- iPads
- Colored images of Islamic art
- Incredible Art Department lesson: Islamic Tile Drawings
- Packets for reading (from Metropolitan Museum of Art website)
- Drawing paper, pencils, tracers, rulers, tracing paper, colored pencils, and markers
- http://www.vam.ac.uk/content/articles/t/teachers-resource-maths-and-islamic-art-and-design/
- Metropolitan Museum of Art lesson plans and resources: http://www.metmuseum.org/toah/hd/geom/hd_geom.htm#slideshow5
- http://patterninislamicart.com/drawings-diagrams-analyses/6/pattern-islamic-art
- http://ed.ted.com/lessons/the-complex-geometry-of-islamic-design-eric-broug
- http://www.nytimes.com/2011/09/25/arts/design/islamic-art-treasures-at-the-metropolitan-museum.html?_r=0
- http://catnaps.org/islamic/geometry2.html#fibonacci
- Architecture tour: http://viajes.elmundo.es/en_360/2012/04/toledogall/tour.html
- Spanish culture: www.espanaescultura.es

Summative Assessment:

Discussion Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Detail	The original post is 5+ descriptive sentences that accurately respond to each piece of the prompt.	The original post is 3-4 sentences that accurately respond to each piece of the prompt.	The original post is not descriptive and does not respond to each piece of the prompt.
Grammar	The post and response comments are grammatically correct.	There are 1-2 grammatical errors.	There are several grammatical errors.
Responses	There are two responses to two different peers that further the conversation with	There are two responses to two different peers that somewhat further the conversation,	Only one response was posted, or the two responses were not meaningful contributions.

	thoughtful questions or meaningful contributions.	but could be more meaningful.	
Citations	Outside sources are accurately cited using MLA style.	Outside sources are cited, but not using correct MLA style.	Outside sources were not cited.

Project Rubric

Criteria	**7-10 points Excellent Work**	**4-6 points Average Work**	**0-3 points Needs Improvement**
Design	The overall design incorporates common characteristics found in Islamic design. It is symmetrical and incorporates geometry.	The overall design incorporates some common characteristics found in Islamic design. It is symmetrical and incorporates some geometry.	The overall design does not incorporate common characteristics found in Islamic design and it is not symmetrical or geometric.
Color Scheme	The design has a specific color scheme applied in a visually appealing manner.	The design has a specific color scheme but could use more variety to be visually appealing.	The design does not have a specific color scheme applied to it.
Creativity	The tile design is original and complex.	The tile design is somewhat original and complex.	The tile design is not original and uses simple elements.
Craftsmanship	The pattern is well balanced. The shading is consistent and the outlining is crisp. The border around it is measured evenly.	The overall drawing is somewhat neatly completed with a few areas in need of improvement.	The overall drawing has much room for improvement for neatness.
Self Assessment	The written self-assessment is in complete sentences and uses vocabulary terms.	The written self-assessment is in complete sentences but does not use vocabulary terms.	The written self-assessment is not in complete sentence format and does not use vocabulary terms.
Reflection summary	The summary has four detailed paragraphs that reflect on the	The summary has three, moderately detailed paragraphs that reflect on some	The summary is not descriptive or all encompassing of the interdisciplinary

	interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	of the interdisciplinary processes, techniques, and/or skills that were utilized throughout the project.	processes, techniques, and/or skills that were utilized throughout the project.

Chapter 4

Reflections and Discussion

The purpose of the research on STEAM curriculum was to examine the existing teaching methods, frameworks, and tools that have been used to integrate the Arts with STEM disciplines. Additionally, the research was collected to determine the benefits of collaborating with cross-disciplines and implementing interdisciplinary curriculum. The purpose of this particular project was to augment the resources for teaching STEAM and fill a void in the secondary education division. As the Arts are still viewed as supplementary to STEM courses in many schools, this project was initiated to advocate for the value of the Arts in education and illustrate how the skills and concepts learned through the Arts enhance the skills and concepts taught in STEM courses.

Fostering interdisciplinary thinking is the overarching goal of a STEAM curriculum. Teaching students to generate creative solutions requires interdisciplinary thinking. Throughout the research process, there was a reoccurring theme of innovation and problem solving as the big idea or objective of STEAM curriculum. Process is viewed as equivalent or more important than product in a STEAM-centered unit. Students are to attain higher order thinking skills such as analyzing, interpreting, evaluating, and creating. In order to support these skills, educators need to act as guides and facilitators who push students to experiment, inquire, and discover.

For this particular curriculum plan there were specific topics or concepts taken from the STEM subjects. Each of the topics had been narrowed down and selected based upon connections between big ideas, opportunity for student choice and collaboration, and integration of similar skillsets. The five interdisciplinary units that were constructed

for this project are not the only options for concepts that combine art and design with STEM. There are a multitude of topics in which the arts and STEM are both present and therefore there is an opportunity for interdisciplinary curriculum. The most efficient way to develop a STEAM unit is to discover overlapping concepts between two or more disciplines and select standards from each discipline and align the standards with the objectives and assessments. Educators should consider their own areas of expertise and content knowledge in addition to the content knowledge of cooperating educators when selecting topics for the STEAM unit plans.

Chapter 5

Limitations and Implications for Future Research

In the STEAM curriculum plan there is an absence of collaboration amongst educators in the co-planning of the units. Ideally, each STEAM unit should involve two or more educators' content knowledge, resources, and existing materials. When two or more educators co-plan and co-teach, it increases the credibility of the content and provides more resources overall. Collaboration amongst educators ensures that the curriculum utilizes the correct content standards and aligns the standards with the objectives accurately.

STEAM is in need of continued research for understanding of effective teaching practices. It would be beneficial for educators to have access to research-based methods of planning and implementing STEAM curriculum. Moreover, there is still limited information on a STEAM program for K-12 schools. In order to adopt a STEAM

program, administrators and educators need to have access to effective models that allow for collaboration and co-teaching amongst departments.

In addition to a need for STEAM research-based methods and models, there is a need for quantitative and qualitative studies on the effectiveness of the curriculum. Further research questions should determine the efficacy and benefits of STEAM practices. For example: Are there academic benefits of implementing curriculum that integrates the arts with logic-driven content areas? Does interdisciplinary curriculum promote holistic learning and innovative thinking more than the seclusion of disciplinary studies? Do the visual arts and STEM students equally benefit from a STEAM curriculum framework? The STEAM movement has been continually growing, but still needs more data to support its efficacy as well as first-hand educator accounts of the feasibility of the execution and student reflections on their perceptions of the influence of interdisciplinary thinking.

Epilogue

In today's continually evolving society we need future leaders who are equipped to solve problems with innovative solutions, collaborate with other experts, discover new processes, and utilize technology to its greatest extent. As stated in Chapter 1, there has been a decline in students who choose to pursue STEM careers but the STEM jobs are growing. In order to resolve this issue, K-12 schools need to make changes to their curricular approaches. Oftentimes students are not aware of the importance of the content that they are provided in school. Students are completing tasks and moving on without truly comprehending information or realizing the purpose of the topics in the school

curriculum. In a traditional secondary school setting, each course operates independently from the students' other courses and each department works in isolation from the others.

A STEAM curriculum and STEAM teaching practices is a viable solution to this problem in education. Cross-curricular lessons and art integration are not new concepts. STEAM takes integration to the next level by changing the perspective of one discipline being supplemental to the other; instead the disciplines are of equal value and are given an equal share in the objectives, learning activities, and assessments. Furthermore, STEAM promotes collaboration, problem solving, and thought processes that transcend a solitary discipline. By presenting interdisciplinary topics to students, they are forced to take on new perspectives and employ skills from more than one content area. Instead of receiving tasks to complete, they are encouraged to navigate their resources and recognize the authentic application of the tools provided to them.

Ultimately, STEAM brings art education into the STEM conversation. The arts are not typically viewed as an essential component to education. With a STEAM approach, the arts are given a chance to demonstrate their value and contribution to contemporary curriculum and instruction. All STEAM educators can cultivate creativity by facilitating interdisciplinary thinking and skills. The arts already promote creativity, critical thinking, and problem solving. When the processes of the arts are combined with STEM there is an even greater opportunity for success and transfer of skills to future studies.

The process of reading through and studying the literature pertaining to STEAM education has influenced my perspective on curriculum and instruction. Prior to my investigation of STEAM curriculum I had only been exposed to integrated art lesson

plans that touched on other subject. This experience has shown me that those lessons are merely superficial as they gloss over supplemental subject matter. In contrast, a true STEAM lesson plan will interconnect multiple disciplines to create a true integrated product. As an art educator I hope to use these concepts and practices from the research to focus my curriculum on higher order thinking skills such as creative problem solving. I desire to have projects that are meaningful to my students and contribute to their future endeavors beyond secondary education. Art education should not be simply learning the proper techniques, history, and principles. The arts should encourage exploration and transferrable skills that have an authentic application.

Although there is still an argument for 'art for art's sake', I want my students to be cognizant of all of the roles that art plays in various fields and careers. Math and science are not devoid of art; art is not an isolated subject. The God who created the heavens and the earth designed the most complex masterpieces that are perfect examples of how math, science, and art are intertwined and dependent on one another. As I delved into the curricular goals of art and STEM courses I was able to see the overlapping concepts. The culminating process of creating unit plans from these goals reminded me of how God's intricate work intentionally combines beauty and logic. It is through my work as an educator that I can acknowledge His great work and glorify Him.

References

Auger, W. F., & Rich, S. J. (2007). *Curriculum theory and methods: Perspectives on learning and teaching*. Ontario, Canada: John Wiley & Sons.

Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. Art Education, 65(2), 40-47

Berk, S. (2016). Designing for the future of education requires design education. *Art Education*, *69*(6), 16-20. Retrieved from http://www.tandfonline.com/doi/citedby/10.1080/00043125.2016.1224844?scroll=top&needAccess=true

Bible Gateway (Ed.). (n.d.). *Exodus 35:31-32* (English Standard Version). Retrieved from https://www.biblegateway.com/passage/?search=Exodus+35

Brock, P., Dunifon, S., & Nagel, L. (2016). Start with a Story: Five Schools and a Zoo Use the One Book, One Community Model to Bridge STEM into STEAM. *Science And Children*, *53*(6), 48-53.

Carr, J., Fauske, J., & Rushton, S. (2008). *Teaching and leading from the inside out*. Thousand Oaks, CA. Corwin Press.

Clapp, E. P., & Jimenez, R. L. (2016). Implementing STEAM in maker-centered learning. *Psychology Of Aesthetics, Creativity & The Arts*, *10*(4), 481-491. doi:10.1037/aca0000066

Dyrness, William A. *Poetic theology: God and the poetics of everyday life*. Grand Rapids: William E. Eerdmans, 2011. Print.

Ghanbari, S. (2015). Learning across disciplines: A collective case study of two university programs that integrate the Arts with STEM. *International Journal Of Education & The Arts*, *16*(7).

Glass, D. & Wilson, C. (2016). The art and science of looking: Collaboratively learning our way to improved STEAM education [PDF]. *Art Education*, *69*(6), 8-14. https://doi.org/10.1080/00043125.2016.1224822

Grinnell, S., & Angal, S. (2016). Luminous lighting: In this STEAM activity, students create wire sculptures that light up. *Science And Children*, *53*(6), 54-59.

Guyotte, K.W., Sochaka, N.W., Constantino, T.E., Walther, J., & Kellam, N. N. (2014). Steam as social practice: Cultivating creativity in transdisciplinary spaces. *Art Education*, 67 (6), 12-19.

Guyotte, K.W., Sochacka, N.W., Constantino, T.E., Kellam, N. N., & Walther, J. (2015). Collaborative creativity in STEAM: Narratives of art education students' experiences in transdisciplinary spaces. *International Journal of Education & The Arts*, 16 (15).

Hannay, M., Kitahara, R., & Fretwell, C. (2010). Student-focused strategies for the modern classroom. *Journal Of Instructional Pedagogies*, 2.

Hempfield School District (Ed.). (2010, June 21). *KUDs 101: Know- understand- do* [PDF]. Retrieved From http://video.hempfieldsd.org/itunes/march/KUDs101.pdf

Keane, L., & Keane, M. (2016). STEAM by design. *Design And Technology Education*, *21*(1), 61-82.

Kurson, R. (2016). Learning about plants with STEAM: In a yearlong unit on plants, students use art to make models of their subjects. *Science And Children*, *53*(9), 58-63.

Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education [PDF]. *Art Education*, *69*(6), 44-49. https://doi.org/10.1080/00043125.2016.1224873

Marshall, J. (2016). A systems view: The role of art in education. *Art Education*, 69(3), 12-19

McClanahan, K. (2016, April 1). The four minutes that changed STEM to STEAM [Blog post]. Retrieved from Americans for the Arts website: http://blog.americansforthearts.org/2016/04/01/the-four-minutes-that-changed-stem-to-steam

Moreno, N., Tharp, B., Vogt, G., Newell, A., & Burnett, C. (2016). Preparing students for middle school through after-school STEM activities. *Journal Of Science Education & Technology*, *25*(6), 889-897. doi:10.1007/s10956-016-9643-3

Quigley, C. F., & Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal Of Science Education And Technology*, *25*(3), 410-426.

Ruppert, S. S. (2006). Critical evidence: How the arts benefit student achievement. *National Assembly of State Arts Agencies*, 1-20. Retrieved from http://www.nasaa-arts.org/Publications/critical-evidence.pdf

Sharapan, H. (2012). From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach. *Young Children*, *67*(1), 36-40.

Shorter, A., & Segers, M. (2016). Ornithologists by design: Kindergarteners design, construct, and evaluate bird feeders. *Science And Children*, *53*(6), 41-47.

The congressional STEAM caucus (Ed.). (2013, February 7). The congressional STEAM caucus. Retrieved June 6, 2017, from Americans for the arts action fund website: http://www.artsactionfund.org/news/entry/the-congressional-steam-caucus

Tillman, D. A., An, S. A., & Boren, R. L. (2015). Assessment of creativity in arts and STEM integrated pedagogy by pre-service elementary teachers. *Journal Of Technology And Teacher Education*, *23*(3), 301-327.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly*, (Spring), 3-12. Retrieved from http://www.stemedcoalition.org/wp-content/uploads/2010/05/BLS-STEM-Jobs-report-spring-2014.pdf

Watson, A. D. (2016). Revving up the STEAM engine. *Art Education*, *69*(4), 8-9.

Wolpert-Gawron, H. (2015, January 26). What the heck is project-based learning? Retrieved May 31, 2017, from Edutopia website: https://www.edutopia.org/blog/what-heck-project-based-learning-heather-wolpert-gawron

Yakman, G. (2008). *STEAM education: An overview of creating a model of integrative education* (Doctoral thesis, Virgina Polytechnic and State University, Pulaski, VA). Retrieved from http://steamedu.com/wp-content/uploads/2014/12/2008-PATT-Publication-STEAM.pdf

Yakman, G. (2012). Exploring the exemplary STEAM education in the U.S. as a practical education framework for Korea. *Korea Association Science Education*, *32*(6), 1072-1086.