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STEM Integration with Art: A Renewed Reason for STEAM

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STEM Integration with Art:
A Renewed Reason for STEAM

By

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M.S., College of Education, 2015
Plan B Project

Submitted in partial fulfillment of the requirements
for the degree of Masters in Science in Natural Science
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Assistant Professor, Dr. Andrea Burrows, Chair
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Assistant Professor, Dr. Adam Myers
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Abstract

For many years, the arts and sciences have been taught in separate silos. However, with the current move in the United States to see its K-12 students perform at the top of the world in STEM disciplines, the arts are being pushed out of the classroom and marginalized in the curriculum. In addition to the limited availability of the arts being taught in schools, there has been a debate that the arts and STEM fields are disconnected from each other. This research bridges a gap in the literature that the arts and sciences are similar in many ways and indicates how STEM can become STEAM in the classroom. A case study of secondary pre-service teachers (n=58) participating in a Science and Art-integration unit, explored how a silk batik art activity could capture scientific and artistic concepts in the same unit over 5 university class sessions for a three-year time period. The research under study aims to answer the follow research questions: 1) how have the secondary pre-service teachers’ perspectives about this Science and Art-integration unit changed over a three-year period; and 2) how has the silk batik activity influenced pre-service teachers’ perspectives of science and art in their future classroom? This study used a mixed methods research approach gathering changes in confidence in knowledge, skills, experiences, and perceptions of science and art. Quantitative and qualitative data are presented that support increased awareness and confidence in pre-service teachers’ perceptions of how science and art can be incorporated into the same classroom, recognition of similarities between the two disciplines, and common themes that are significant in teaching science and art disciplines together. Evidence from the research suggest that the Science and Art-integration unit not only serves to promote appreciation and learning for each discipline, but also helps to develop skills and creative perspectives needed beyond the classroom in STEM and other careers.
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Chapter 1 – Introduction

This introduction will explain the problem of the arts are being marginalized in schools, a need for both art and science in schools, previous research done about STEM integration with the Arts, the purpose of this study, and the research questions of focus.

The Problem: The Marginalization of Arts in Schools

Beginning in 1996, the National Science Foundation married science, technology, engineering, and math to create STEM when the National Science Education Standards, the National Council of Teachers of Mathematics, and the International Technology & Engineering Educators Association placed high value on these core subjects to produce constructed guidelines for classrooms to better prepare K-12 students for careers in these fields (Woodruff, 2013). President Obama stated in 2008, “Today, more than ever before, science holds the key to our survival as a planet and our security and prosperity as a nation. It’s time we once again put science at the top of our agenda and work to restore America’s place as the world leader in science and technology” (Land, 2013, p. 547-548).

There has been much discussion where the boundary lies between the arts and sciences in the classroom. That discussion has resulted in a variety of responses across the spectrum, to the point where the arts are slowly being eliminated from the education system. With the push for future K-12 students to lean towards fields such as science, technology, engineering, and math (STEM), and the support from the Obama administration in the STEM movement, the arts are being marginalized in schools (Wynn & Harris, 2013). Courses in the arts are either being phased out or limited in school schedules. LaMore et al. (2013) explain that with other subject areas being of top concern, the arts are under the current assumption of being seen as “dispensable extras” (p. 221). Therefore, there have been public policy decisions made to
decrease or eliminate funding for the arts in many communities and schools (Sousa, 2006; LaMore et al., 2013). Gurnon, Voss-Andreae, & Stanley (2013) add that for many arts and STEM courses are offered at the same time in schools and K-12 and college-level students find it difficult to participate in both types of classes. This scheduling issue prevents mixing and transference of knowledge to occur in between disciplines in the first place.

**A Need for Both Art & Science in Schools**

In fact, science and art are viewed as having no connections in many schools. There is such disconnect, that curricula outside of the visual arts remain impoverished by a lack of visual learning strategies (Baldwin & Crawford, 2010). In reality, there is not as big a gap or difference between these two disciplines, rather there are overlapping similarities and needs for each other. Land (2013) states, the arts are not only similar to the STEM fields, but are able to “re-invigorate the educational platform, providing not only an interesting approach, but also opportunities for self-expression and personal connections” (p. 548) that are highlighted within the current 21st century society.

The 21st century has challenged and changed our modern professional and educational realms by advancing and changing our technologies, skills, and literacies. In order for society to keep up with this fast paced and advanced intelligence, individuals must acquire knowledge on “how to work collaboratively within a collected intelligence, participate in social networks, negotiate across cultural differences, and navigate contradictory data available to them” (Land, 2013, p. 549). Together, convergent and divergent thinking builds into the development of a set of skills necessary to be successful in today’s society. Combining arts and sciences, serve (grade level not specified) students’ appreciation and learning for each discipline, and develops life-long skills and creative perspectives needed beyond the classroom. Milkova, Crossman, Wiles, &
Allen (2012) agree that the integration of the two can teach individuals to think critically, creatively, and collaboratively. Along with these skills, additional skills such as problem solving and innovative thinking are developed through scientific and artistic collaborations (Mote, Strelecki, & Johnson, 2014). Success and progress is not accumulated by just knowledge and technology, but come from the melding of technology and creativity. Science, technology, engineering, art, and mathematics (STEAM) push to reincorporate creativity and innovation into (grade level not specified) students for all-around success and a toolbox of skills (Land, 2013).

**Previous Research of STEM Integration with the Arts**

This paper presents a longitudinal perspective on STEAM (or a science and art education combination) at the same institution where previous examination of the curriculum had occurred. In a mission to transition classrooms from STEM to STEAM, how does this process occur? It starts with the educators themselves in providing them with knowledge, ideas, and confidence to be able to teach multiple disciplines in the same classroom.

While there is known research that the sciences and arts should not be taught in separate silos, but together in a balance (Nichols & Stephens, 2013), how are teachers being inspired to direct this change from STEM to STEAM? In a previous study conducted at the same institution, prospective science and art educators (pre-service teachers) were brought together to participate in a Science and Art-integrated activity. Apart of separate Science and Art Methods courses, the participants, known as pre-service teachers, came together for a combined unit of science and art integration. The pre-service teachers were asked to design pieces of art through silk batik painting that represented secondary school science curriculum (Medina-Jerez, Dambekalns, & Middleton, 2012).
This specific Science and Art-integrated activity has continued over the past ten years using satellite imagery as a catalyst to visualize a scientific concept (Dambekalns, 2005). Dambekalns (2005) articulated that the idea of using art projects to convey scientific concepts, such as the satellite imagery, allows for understanding of Earth processes and geological features, map interpretations, and artistic application techniques to visually represent the landscape of the Earth’s surface. Through the previous research, data have supported the idea that exposure to the science and art disciplines, together, increases the knowledge of the integration between the two disciplines and incorporates science and art into future classrooms by pre-service teachers (Medina-Jerez et al., 2012).

Currently, the silk batik activity research is continuing to be conducted today through a western university’s college of education. The researcher is using previous research (Dambekalns, 2005; Medina-Jerez et al., 2012) and a Science and Art-Integration unit within the current Science and Art-Methods courses as a springboard to address STEAM from a participant/observer point of view in an ethnographic design through mixed methods research. The researcher focuses on how pre-service teachers are unobstructed or obstructed to the idea of science and art being incorporated into the same classroom, as well as how these pre-service teachers are being inspired or uninspired to utilize interdisciplinary learning into their future classrooms.

Purpose

Within this decade-long project, findings have been discovered based on the foundational research of this project (Dambekalns, 2005; Medina-Jerez, Dambekalns, & Middleton, 2012), however, not much analysis has occurred based on recently collected data. Following the article
written by Medina-Jerez et al. (2012), the next three-years were undocumented (years 2009 through 2011). However, data were collected again starting in 2012.

The researcher came across this pre-existing study through her Science Methods course instructor. Since the Science and Art-Integration unit has been under her course instructor’s facilitation for the past 3-years, the instructor (as her research committee’s chair) allowed the researcher to carry out the research by utilizing previous data that had been collected (outside of the researcher’s participation) and in addition, collecting new data through observations, interviews, and presentations.

The researcher uses an ethnographic design with a mixed methods approach for this study. The data collected from 2012 through 2014 science and art-integration units will measure pre-service teachers’ perspectives of integrating science and art in the same classroom as an extension from Dambekalns original research. The purpose of this research is to identify and measure if pre-service teachers’ perspectives changed, making them more amenable to utilizing disciplines out of their concentration into their teaching, but also to measure whether this specific science and art-integrated activity of study influenced or not pre-service teachers to want to incorporate other disciplines into their future classrooms. Through an analysis of pre-service teacher perspective change over time and information observed from the researcher (as a participant), the researcher provides an impression of science and art being currently integrated into the classroom specifically through this study.

**Research Questions**

- How have pre-service secondary teachers’ perspectives about this Science and Art-Integration unit changed over a three-year period time?
• How has the batik activity influenced pre-service teachers’ perspective of science and art in their future classroom?
**Chapter 2 – Review of the Literature**

This chapter will first provide and explain an introduction and history of science, technology, engineering, and math (STEM) in K-12 schools. Next, this chapter will provide background literature on 21st century skills obtained through art and science, and how an interdisciplinary approach is used within the Next Generation Science Standards and the Wyoming Fine and Performing Arts and Science standards. As the background literature continues, there is a comparison between the science method and creative process, a dissection of the creative thinking process, the importance, art, and science observation, and examples of creative scientists. Concluding this chapter, an explanation is provided on how the arts add meaning into the STEM framework and provides examples of how STEM and the arts are being integrated together.

*Science, Technology, Engineering, and Math in K-12 Schools*

With the push for the country’s K-12 students to rise with success to the top of the lists in science and math, STEM has influenced America’s classroom (NRC, 2011). Reeve (2015) explained there is a need to prepare our country’s K-12 students for STEM careers that are needed in the modern workforce. STEM is involved in almost everything within our modern world, and so there is a need for an educated society that is literate in science and technology. As STEM merges into the classroom, these disciplines are able to benefit the K-12 student-learning environment.

As discussed by Wang, Moore, Roehrig, & Park (2011), STEM in the classroom deepens (grade level not specified) students’ understanding by contextualizing concepts, broadening minds about related fields, and increasing interest in STEM careers. Reeve (2015) continued to add that STEM courses promote thinking where (grade level not specified) students are
“purposely thinking about how STEM concepts, principles, and practices are connected to most products and systems we use in our daily lives” (p. 8).

There is more to a learning process than just a standard direct instruction or lecture-based lesson. STEM education often utilizes more meaningful learning experiences by incorporating inquiry and structured activities that promote and develop a skill set that is successful for self-thinking, analyzing, and problem solving. Trueman (2014) concluded that individuals are more likely to gain skills needed for STEM thinking through structured problem solving. She added that the skill of problem solving that this type of education fosters, allows for them to gain deeper understanding of the content being taught and the ability to solve contextualized problems. For example, Trueman’s case study focused on how an ecology course measured the confidence and understanding levels of a given environmental issue when exposed to an inquiry-based activity. The ecology college students were given the opportunity to approach their environmental issues through scientific inquiry and problem solving processes. Their confidence and understanding levels were assessed through completed assignments such as: an issue-topic plan, an environmental assessment, and a survey based on inquiry, content, and data collected directly by the college students. At the end of the study, results showed significant enhancement of college students’ ability to understand ecological environmental issues and content based on their experience and gathered information from the inquiry-based activity. The ecology college students connected the learning experiences from the activity to problem solving skills used in the data and research collection process (Baldwin & Crawford, 2010; Land, 2013; Trueman, 2014; Ursyn, 1997).

STEM disciplines should not be taught in individual stand-alone segments; when combined together, they bring a realistic approach into the classroom. Wang et al. (2011) explains, the integration of the four STEM-disciplines fostered awareness for our future
generations of real-world problems, situations, and issues by providing realistic perspectives, initiatives, solutions, and analytical-thinking. Students could succeed in integrated STEM curricula through the incorporation of real-world scenarios, the creation and exploration of research questions, and construction of their own knowledge through a meaningful learning environment (Burrows, Breiner, Keiner, & Behm, 2014). Through the previous research (Wang et al., 2011; Burrows et al., 2014), if many STEM disciplines are learning to connect their curriculum with each other into the classroom, then other disciplines, such as art, should be incorporated into this realistic, interdisciplinary approach.

An Interdisciplinary Approach Used in the NGSS and Wyoming State Standards

Content and performance educational standards, such as the Next Generation Science Standards (NGSS), Wyoming State Fine & Performing Arts, and Wyoming State Science Content and Performance Standards have incorporated “leg-room” for an interdisciplinary teaching approach for teachers to use in their classrooms. This “legroom” provides teachers to connect curriculum from the sciences and arts in their classroom while following educational standards to offer identical opportunities for techniques, skills, and experiences to be learned in either setting. While examining the NGSS and Wyoming State Science and Fine & Performing Arts Content and Performance Standards, there is linkage between the two disciplines within their standards. Please see Table 1 in Appendix A for a comparison between the standards.

Wyoming State Standards

Wyoming State Standards for both the sciences and the fine and performing arts include flexibility for interdisciplinary learning and connecting content vocabulary and knowledge to other disciplines. In addition to incorporating connections with other disciplines and fields, the Science and Fine & Performing Arts Content and Performance Standards, share similar standards
with one another. Each discipline’s standards develop ideas of understanding core content vocabulary and concepts. Upon understanding core concepts, K-12 students act out by doing, creating, or performing activities through exploration and investigation to enhance understanding of techniques, vocabulary content, and concepts. Finally, K-12 students can then connect the content to their personal lives, society, and culture.

**Science Content & Performance Standards**

Provided by the Wyoming Department of Education (2008), the Wyoming State Science Content and Performance Standards offers three overarching standards that apply to what K-12 students should know, understand, and apply in science. The three overarching standards for science include:

1. **Concepts and Processes** – K-12 students develop understanding by blending content and processes, and highlighting the connections among scientific ideas;

2. **Science as Inquiry** – K-12 students are able to safely conduct investigations and develop understanding of inquiry, enriching their knowledge of science; and

3. **History and Nature of Science in Personal and Social Decisions** – K-12 students understand and act on personal and social issues by incorporating historical views that acknowledge scientific events of significant value and influence our cultural heritage.

Through these three overarching standards for science, K-12 students are able to demonstrate understanding of knowledge, skills, and techniques that help execute scientific methods and enhance higher levels of thinking. Wyoming’s Department of Education (2008) recognizes that understanding science is a dynamic process and that scientific content is best learned through investigation. Wyoming’s Science Content and Performance Standards allows
K-12 students to use a scientific method in creating their own research questions, and conduct investigations to explore, collect, analyze, and interpret their data in order to explain phenomena that relate to our society. After the act of doing science through inquiry to create understanding of concepts and content, K-12 students are able to fully understand science when relating concepts and content to personal and social issues and views. The third standard that allows for science content to link to historical and cultural views adds meaning to learning, purifies different views of scientific inquiry and enriches the role science plays in society to understand natural phenomena.

**Fine and Performing Arts Content & Performance Standards**

The Wyoming Fine & Performing Arts Content and Performance Standards offer four standards for the visual arts, dance, music, and theatre. From the Wyoming Department of Education (2013), no matter the art field, the standards include:

1. **Creative Expression Through Production** – K-12 students create, perform, exhibit, or participate in the arts;
2. **Aesthetic Perception** – K-12 students respond to, analyze, and make informed judgments about the arts;
3. **Historical and Cultural Context** – K-12 students demonstrate an understanding of the arts in relation to history, cultures, and contemporary society; and
4. **Artistic Connections** – K-12 students relate the arts to other disciplines, careers, and everyday life.

The four standards for the Fine and Performing Arts educates K-12 students on the techniques, processes, and uses of materials while offering opportunities for K-12 students to connect what they have learned in art classes to other disciplines throughout all grade-levels. By
using these standards, teachers are able to help K-12 students create work based on design elements, principles, and key vocabulary while collaborating with others in a creative, artistic process. In addition to collaboration and creation of work, K-12 students learn to observe the physical properties within artwork and their surroundings. The Wyoming Department of Education (2013) includes in the standards that through observation, K-12 students learn to explore and develop connections between works of art and the elements and principles behind them while defending personal preferences for artists, styles, and works. K-12 students define personality by developing their own artwork through key processes and techniques and understand history, environment, and cultural reasoning behind artwork. The Fine and Performing Art Standards combine the creative expression, aesthetic perception responses, and cultural and historical context with the last standard of artistic connection. The fourth and last standard revolves around how the arts relate to other disciplines in the educational curriculum, future careers, and everyday life. The artistic connection standard allows K-12 students to identify principles and subject matter in other subjects or fields, understand the artistic skills and components associated with many careers, and how contributions can be made towards a community or society in an artistic manner.

In addition to the Wyoming State Standards, The Next Generation Science Standards (NGSS) are incorporating the idea of interdisciplinary learning, incorporation of skills and techniques, and crosscutting concepts that can be used in conjunction with other disciplines. Even though the NGSS are built upon the original science education standards, these Next Generation Science Standards encompass a deeper understanding of scientific core ideas through three-dimensions. These three dimensions include: disciplinary core ideas, scientific and engineering practices, and crosscutting concepts. Working together, the three dimensions provide engagement through active learning in project-based learning strategies and provide exploration
through meaning and relevance to real-world situations (Krajcik, 2015). The NGSS contribute to powerful learning opportunities by promoting strategies and identifying resources that prepare K-12 students to do science and use science to make their communities better places to live (Penuel, Harris, and DeBarger, 2015).

One of the three dimensions focuses on crosscutting concepts. Specifically, the crosscutting concepts of the NGSS provide linkage across all domains of science (NGSS Lead States, 2013). There are seven crosscutting concepts provided by NGSS Lead States (2013): patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter in systems; structure and function; and stability and change of systems. Within these crosscutting concepts, not only can these concepts be linked across a variety of science fields, but many of these concepts can be defined through an artistic interpretation and perspective. For example, with the use of the NGSS in curriculum, K-12 students are able to develop series of products or artifacts to address problems or questions by constructing models (one crosscutting concept). Developing and using models helps make sense of phenomena and justify one’s position using evidence (Krajcik, 2015). Penuel, Harris, and DeBarger (2015) elaborate that models enhance learning with a more specific example of how teachers construct models that explain why and how air can be compressed and expanded in a syringe by demonstrating what happens by physically using syringes and drawing diagrams to visually depict what they could not see. Krajcik (2015) adds that models constructed by (grade level not specified) students provide opportunities for them to engage in scientific practices such as engaging in argument from evidence and communicating scientific information and ideas about a phenomenon. The construction of models influences collaboration with others to share ideas, receive and give feedback and reflect on work (Krajcik, 2015).
Within educational standards, such as the NGSS and the Wyoming State Fine & performing Arts and Sciences Standard, there are opportunities for interdisciplinary teaching and connections of other disciplines in a classroom. Through interdisciplinary learning, the sciences are able to complement the arts and vice versa. Both science and art explain concepts with visualizations, perspectives, and outlooks through a lens of engagement and meaning. “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 (Bequette & Bequette, 2012, p. 43). Friedman (1997) explained that “art can put science into perspectives by creating an emotional need to understand concepts of science” (p. 5), but also allows science to be incorporated into an artistic perspective. The two can balance each other in an educational setting by promoting understanding for individuals varying learning styles. The flexibility and varying perspectives that each discipline contains can promote project-based learning and constructivism (Milkova, Crossman, Wiles, & Allen, 2012).

Essentially, the arts provide development of skills that are necessary for group survival. Skills that the arts develop include a variety of thinking tools, such as: “pattern recognition and development; mental representations of what is observed or imagined; symbolic, allegorical, and metaphorical representations; careful observation of the world; and abstraction from complexity” (Sousa, 2006, p. 27). The arts also contribute to realizing bigger perspective and breadth of human experience, meaning, and other complex forms of thinking.

The arts can be molded and morphed to reflect and visualize science, but can also entice engagement for learners. It was stated by Friedman (1997), that there are three ingredients for successful learning environments: what is going to be learned, how the information is going to be
learned, and what is the desire to learn? The arts can create that emotional and inspirational
desire to learn (Friedman, 1997). Opportunity occurs when there is time for mixing and the
disciplines are taught in the same classroom (Gurnon, Voss-Andreae, & Stanley, 2013). “By
inspiring curiosity, a specialty of art-science collaborations, we provide motivation to learn
(Gurnon et al., 2013, p. 1). This connection opportunity allows for individuals to be more
creative in general, ignite curiosity, and promote collaboration between different individuals.

A Comparison of the Scientific Method & the Creative Process

Are educators about to easily incorporate science and art connections into the same
classroom for an interdisciplinary learning approach? By looking at the reviewed educational
standards of science and art and the skills that both disciplines develop, this opportunity is
possible. However, are the sciences and the arts on complete opposite ends of the spectrum?
Quite the contrary, the sciences and arts are quite similar as far as resolving problems. When
examining the processes, the “processes bring about a certain kind of thinking and intended
outcomes” (Bequette & Bequette, 2012, p. 40). An example, Needle et al. (2007) confirm this
strategic process based on research conducted with biology and art undergraduates examining
zebra fish brains. The undergraduates under study used a series of processes in their lab in order
to determine how to extract the fish brains for observation, photographic records, and research.
Nichols & Stephens (2013) add that “the scientific method and creative process are cyclical and
similar to each other” (p. 5); these two design plans include: posing a question or problem,
conducting experiments to help answer the problem, analyzing findings, and presenting results,
followed by a new round of questions and the cycle repeats itself. Both processes help explore
one’s critical thinking skills and abilities to problem solve an issue or challenge.
**Dissecting the Creative Thinking Process**

While both the creative process and scientific method allow for artists and scientists to approach problems in the same structured way, however, both the arts and sciences bring another set of thinking skills to the overall learning experience. Separately, the sciences and the arts contribute to different modes of thinking. This is similar to how people refer to each side of the human brain where one side contributes to a specific quality compared to the other half. The sciences contribute to convergent thinking, while the arts contribute to divergent thinking (DeHaan, 2011; Madden et al., 2013; Zubrowski, 1982).

Together, when convergent thinking and divergent thinking are combined, they mutually benefit an individual to think creatively. When looking at creative thinking (or creativity), its relation to higher order thinking encompasses convergent thinking (analytical thinking), but also includes divergent thinking (associative thinking) for the learner. Convergent (analytical) thinking is the process where a (grade level not specified) student is able to reach one solution to a problem, whereas divergent thinking (associative) involves exploring many possible solutions to a problem (Madden et al., 2013). Combining both forms of thinking allows creativity to occur that benefits higher order mental thinking and problem-solving skills (DeHaan, 2011). DeHaan (2011) explains, “Creative thinking is the most complex abstract of the higher-order cognitive skills to Bloom’s taxonomy of learning” (p. 1499). Bloom’s taxonomy of learning breaks down how individuals are able to hone specific parts of thinking processes, including: analyzing, synthesizing, and understanding problems.

Alongside the analytical, convergent side that the sciences establish in thinking, the arts help (grade level not specified) students focus on the divergent, associative, and creative aspect of thinking. Creativity influences higher order thinking skills and strategies and brings the
integration of science and art to a whole new level of importance. Divergent thinking through the arts is incredibly important to the success of (grade level not specified) students in the classroom and in their professional life. Divergent thinking progresses into a skill needed for economic, social, and future successes (DeHaan, 2011).

Convergent and divergent thinking processes when used in conjunction with each other promote play, exploration, and deeper learning (Zubrowski, 1982), but encourage the individual to test ideas, question issues, and find solutions that may not always result in a single ‘correct answer’ but to multiple ones. DeHaan (2011) explains that creativity embodies the ability to restructure problems and produce solutions through innovative thinking that are useful and critical to success. More so than finding multiple solutions to problems, creativity also promotes collaboration. Creativity increases peer-to-peer interactions (as with brainstorming) and prolongs associative thinking. Working together and consulting with others is a key skill that is significant to career and academic success.

Even as early as 1982, researchers compared scientists and artists and concluded that both tap into their creativity at the same deep, mental processing level where art can be used as an aesthetic approach model to guide learning. Ursyn (1997) stated, “art is a vital part of education not only because it helps (grade level not specified) students learn basic skills, but because those skills help develop the excellence of higher mental processes” (p. 68). DeHaan (2011) amplifies that creativity helps people approach problem solving with higher order mental operations and revolves around the convergent and divergent thinking aspect. One of MIT’s computer science professors, Erik Demaine, confirms this significance explaining, “Creativity is required for thinking in science as being the same as for art (Lovelace, 2014, p. 74).
The Importance, Art, and Science of Observation

There is a constant demand for the arts in schools because of the development of essential skills and of the brain itself. The arts, such as image producers or drawing, contributes to whole brain development to enhance learning (Sousa, 2006). For instance, Sousa (2006) explains the idea of creating images allows for visual cues to enhance learning objectives such as imaging and imagining. Sousa (2006) implies,

Imaging is the visualization in the mind’s eye of something that the person has actually experienced; imagining depicts something the person has not yet experienced and, therefore has no limits (p. 30).

An example of a skill that both disciplines rely on is the skill of observation. Observational skills are incredibly significant to many careers in the scientific, artistic, and medical professions. “Galileo and Leonardo da Vinci used drawing both to observe and to learn” (Baldwin & Crawford, 2010, p. 26). Root-Bernstein & Root-Bernstein (2013) explain there are many types of sensory observations that can be fostered in scientific practices. However, most individuals have little experience beyond early childhood in using visual representations, and we come to realize that “the importance of drawing is largely devalued in primary schools, and (grade level not specified) students come to believe it is used only for occupational or recreational purposes” (Baldwin & Crawford, 2010, p. 28). The arts are incredibly significant for a child’s development for future career paths and adult successes.

When scientists are able to learn to draw their own observations, they gather the skills to help them collect data that is gathered in a variety of ways (visually, aurally, tactile, olfactory, and gustatory) (Root-Bernstein & Root-Bernstein, 2013). Pellico, Friedlaender, & Fennie (2009) supported the idea of researchers using the arts to enhance observation as well. For example,
Dempsey & Betz (2001) provided a lesson on how to teach artistic drawing techniques to biology undergraduates in order for them to understand anatomical and microscopic concepts. A similar study was performed by Baldwin & Crawford (2010) where a visual arts teacher assisted a botany teacher by providing a drawing tutorial specifically designed to help botany undergraduates understand and visually communicate parts of plant specimens.

Careful observation and interpretation of specimens, nature, and microscopic research are key components utilized in the scientific and creative processes (Dempsey & Betz, 2001). Kangas (1998) implies that through his ecology and art lesson, (grade level not specified) students are able to use observational skills to evaluate ecological content within provided works of art. The provided paintings feature animals and ecosystems where his (grade level not specified) students are asked to use their observations and pre-existing ecological content knowledge to differentiate between paintings that portray ecological balance in flora and fauna diversity and identification of realistic habitats (Kangas, 1998).

With a keen eye to specific detail, (grade level not specified) students are able to make connections between the lecture-content and hands-on field/lab experiences, interpret information through different modes of thinking, and develop an organizational reference tool (Baldwin & Crawford, 2010). One of Baldwin & Crawford’s (grade level not specified) students explains, “I learned how much easier it is to learn things after you draw/diagram them out…I think you really have to process something before you draw it, so it implants in your memory” (p. 30). While many (grade level not specified) students are obscured to use electronic media, they lose creativity skills by not practicing the art of generating personal images they observe (Sousa, 2006). Visual representations are able to assist in connecting a (grade level not specified) student’s understanding to lecture-content or information.
Arts Adds Meaning to the STEM Framework

The country’s goal for pushing STEM into classrooms is not solely about expanding the United States’ presence in the science and technology industry of the world; the goal also includes making science meaningful to our K-12 students. This meaning is made relevant when the arts and culture are incorporated into STEM. Zeidler (2014) explains that “science needs to be more interesting and relevant” (p. 4) for all global citizens whose everyday actions and decisions inevitably impact all. The idea of incorporating the arts culture into STEM can bring personal meaning and relevance to an individual’s learning experience. The argument continues that K-12 students are struggling to connect to science fields because these topics are impersonal, irrelevant, and removed from their immediate lives (Zeidler, 2014). How can teachers make their STEM classrooms more engaging, more meaningful?

“Science educators should identify interests, experiences, and cultural practices relevant to young people’s everyday lives, and instruction should use these to support learning” (Penuel, Harris, & DeBarger, 2015, p. 46). By making curriculum personal, it provides thoughtful connections of how science ties together with an individual’s life. This is when culture contributes to science and adds “legitimacy and value” (Zeidler, 2014, p. 5). Lack of legitimacy and value can be traced back to Nichols & Stephens’ (2013) idea of separated subject-silos in school. Being separated, there is little connection from discipline to a (grade level not specified) student’s life. By breaking down these subject-specific walls, there is an opportunity for different disciplines to come together with a cultural stance, which inherently develops a personal meaning to understand not just science, but anything (Nichols & Stephens, 2013; Zeidler, 2014).

So, Arts + STEM = STEAM. From what previous literature and research presents, the Arts + STEM adds richer learning experience for an individual. Learning to use a critical and
creative mind to solve a problem, all while having a personal and meaningful connection to that individual’s everyday life, develops 21st century skills. The culture and personal perspective that the arts bring to an individual’s learning contributes to different ways of perceiving, knowing, and dealing with the world; it helps expand the toolbox of what STEM stands for (Wynn & Harris, 2013). However, another question is revealed: How are pre-service teachers being influenced to incorporate science and art into the same classroom?

**Examples of Creative Scientists**

Examining our history, there are many well-known individuals that have utilized their creative side to help advance them in the scientific field. Established scientific individuals such as: Galileo, Einstein, Luis Alvarez, Richard Reynman, and even Leonardo Da Vinci admitted to being involved in playing music, painting, drawing, and other fields of the arts (Baldwin & Crawford, 2010). Due to their participation in the arts, they have admitted that their art activities were the “driving force behind their scientific intuition” (p. 16) in some way, shape, or form (Root-Bernstein & Root-Bernstein, 2013). According to the American Association for the Advancement of Science (1990), the Nature of Science is a blend of logic and imagination where scientific concepts do not emerge automatically from data or from any amount of analysis; but through invention of hypotheses and theories, scientists can test their questions of reality in a creative manner. The Nature of Science implies that “knowledge and creative insight are usually required to recognize the meanings of the unexpected and questioned” (AAAS, 1990, Science is a Blend of Logic and Imagination section, para. 16). Madden et al. (2013) explains that solely focusing on STEM thinking of facts and content precludes the ability to think creatively, however, when the arts are intertwined with STEM disciplines, scientists of multiple disciplines are able to collaborate mentally and physically, enabling creativity to blossom. Madden
emphasizes that when (grade level not specified) students initiate creativity into their thinking, they are able to identify issues, problem-solve, communicate thoroughly, develop good organization, manage others, inhibit creative and innovative thinking, and cultivate content understanding.

Root-Bernstein & Root-Bernstein (2013) explain there are a number of disciplines/skills that the arts can facilitate, not just for artists, but scientists as well. LaMore et al. (2013) interviewed scientists that explained artistic activity in their scientific work: they were able to have personal advancements in communication and mental skills, better hand-eye coordination, better tool use, more creative imagination, and more collaboration among peers. Art can be a trigger and muse for advancements in specific technologies and discoveries. For instance, at the Massachusetts Institute of Technology (MIT), Erik and Martin Demaine, two faculty in computer science, and artists in residence, utilize their paper-folded origami art to capture the mathematical theory behind their creations. Erik Demaine’s research with his art has helped launch MIT’s computational origami field (Lovelace, 2014). Lovelace (2014) emphasizes Erik Demaine’s work in research and art as a combination of new technology with a craft that has stimulated an environment for the art world at MIT. Another example from Burrows, Borowczak, Keiner, & Behm (2012) included research about designing computer programs by pre-collegiate teachers and how the activity helped expand knowledge of creative inventiveness and technique of computer sciences into the enhancement of K-12 student success in STEM classes.

An Opportunity for STEM & Art Integration

STEM programs that integrate the arts can provide more breadth, engaging, and meaningful learning experiences for K-12 students. In fact, programs that incorporate both the
arts and other curriculum areas offer the most powerful effects where both K-12 students and teachers are able to understand how the arts are viewed while generating conditions that are significant for K-12 student learning (Sousa, 2006). Sousa (2006) continues that research studies have shown positive benefits for arts integration with other disciplines,

(Grade level not specified) students have a greater emotional investment in their classes; students work more diligently and learn from each other; cooperative learning groups turn classrooms into learning communities; parents become more involved; teachers collaborate more; art and music teachers become the center of multi-class projects; learning in all subjects becomes attainable through the arts; curriculum becomes more authentic, hands-on and project-based; assessment is more thoughtful and varied; and teachers’ expectations for their students rise (p. 31).

In a collaboration program from the University of Wyoming News, called “The Ucross-Pollination Experiment,” four of the University’s top scientists and artists were joined together in pairs to produce original works of arts. According to UWNews (2014), the collaboration depicted “struggles and stories behind these genuinely integrative works of scientific art” (para. 4). In addition to stories and struggles, the collaborations by the experts explained how “divergent fields of inquiry and exploration truly listen to one another” (para. 4). Through the presentations of the collaborative works of art, the experts talk about scientific processes, concepts, and research, with an emphasis in the creative arts; all while producing a work of art that creatively conveys the scientific concepts or research. The experts utilize each other’s background to combine the two fields. One particular presentation focuses on experts of rangeland ecology and sculpture describe their experience working together. Ashley Hope Carlisle, a sculptor through the University of Wyoming’s Art Department, explains, “It’s just
been amazing to have this relationship, this back and forth. All of these works were done as a balance between Ann and I; compromising, listening and responding to each other and I cherished it” (Wyoming Videos, 2014). Throughout the Ucross-Pollination Experiment, the artistic and scientific expert pairs are in the field together, observing together, teaching each other, and learning from each other, all while working together to create a work of art. Wyoming Videos (2014) documents Carlisle adding more enlightenment about the collaborative shrub sculptures that she and Ann Hild created, “And that is also so amazing about this experience, is that you are not only a teacher in this realm, but you are a (grade level not specified) student as well, and we have done both the entire time. Hopefully she has gotten a lot from me, I know I have gotten a lot from her.”

If the ideal mission is to transition schools from STEM to STEAM in order to foster richer, critical, creative, and well-rounded K-12 students, how does progress occur? It starts with the educators themselves. Successful instruction is an important component in motivating K-12 students; therefore the need to upgrade the knowledge and confidence in our educators is an equally important component to that motivation (Burrows et al., 2012). The study conducted highlighted workshops for pre-collegiate educators about science presented with art-related overtones that show how science and art are vitally important to problem solving and to feel an increase in confidence in both disciplines.

These professional development workshops allow educators to explore lessons that utilize scientific and engineering practices while creating a physical product. Not only are these pre-service teachers being given new ideas on what to teach in their future classrooms, but are able to build relationships with one another to collaborate over ideas and thoughts (Burrows et al., 2012). Wynn and Harris (2013) identify that STEAM provides the opportunity for teachers (pre-
service or current classroom) to gain confidence and utilize each other and the surrounding community to develop partnerships based on the strengths of others.

Reflecting back to the research from Medina-Jerez et al. (2012), integrated learning experiences are an effective way to improve pre-service teachers’ self-ratings of knowledge and ability to develop and engage their secondary students with interdisciplinary connections. In this form of professional development, pre-service teachers are exposing their future secondary students to real-life tendencies and experiences, ill-defined problems through investigation and real-life design, and providing opportunities for higher-level thinking skills to develop. Overall, pre-service teachers are providing a learning environment that improve their secondary students’ learning and prepare them for successful, real-world careers in their future classrooms.

Giving pre-service teachers the opportunity to explore and investigate new ideas, concepts, and techniques, can enhance teachers’ knowledge, skills, and confidence in disciplines where they have little-to-no formal collegiate experience (Burrows et al., 2012). Professional development workshops could provide confidence in actually teaching these disciplines, but also inspire pre-service teachers to repeat these activities in their future classrooms. The offered professional workshop also sets up additional opportunities for pre-service teachers to utilize other resources and faculty in their schools for support. Mote et al. (2014) adds that when schools utilize art and design in all their classes, classroom teachers are able to collaborate with each other while revolving around a common theme to create meaningful and positive learning environments and activities.
Chapter 3 – Overview of the Project

This chapter dissects the Science and Art-Integration unit that the pre-service teachers participated in during the 2012-2014 years under study. Definitions of terminology commonly used in the science and art-integration unit are addressed, a breakdown of the unit’s sessions and setting (introduction, exploring connections through a sampler, small group silk batik subject consensus, finishing the small group silk batik, and presentations of and art and science-integration understanding).

Definitions of Common Terminology in the Science & Art-Integration Unit

- **Science and Art-integration unit** – an interdisciplinary approach incorporating science and art curriculum into a single unit using a single activity designed-lesson to create a specific product
- **Pre-service teachers** – undergraduate or graduate education students (secondary education)
- **Cohort** – an individual semester of Science & Art Methods courses coming together for a Science & Art-integration unit.
- **Perspective** – the combination of attitudes and confidence levels of science and art content, skills, and experiences derived the specific integration unit
- **Silk Batik** – a technique used to hand-dye fabrics (i.e. silk). Wax resist (resin – dye repellent) is applied to cover parts of a design. Colored dyes are applied to the non-resin areas. When finished, the wax is dissolved under hot/boiling water to reveal the contrasting lines & non-dyed areas
- **Macroscopic Image**: visual representation of an object, organism, or something that is large enough to be seen with the naked eye
**Microscopic Image:** visual representation of an object, organism, or something that is so small, it is invisible without the use of a microscope

**The Science & Art-Integration Unit: Design of Unit**

The project presented here brought together aspiring science and art pre-service teachers for over a decade. Each year, pre-service teachers of Science and Art Methods courses of a western university worked together in an integrated unit of the fall semester. The Science and Art Methods courses served as an introduction to science and art teaching. The main focus of the courses was to identify attributes of teaching and learning science or art that are important to effective instruction. The Methods courses offer pre-service teachers to explore teaching approaches and strategies, review national reform documents and standards, and learn about major issues in their fields. Within the Science and Art Methods 16-week courses, the pre-service teachers of each field get together in a 5-session Science and Art-integration unit. This unit takes up a third of the course, which provides a significant impact of focus on how science and art can be integrated into the classroom through an exploratory and hands-on example activity. Please see Appendix B for the Science Methods Course Syllabus.

During each cohort’s integrated science and art collaboration unit, the science and art pre-service teachers were asked to design and paint pieces of art onto silk canvas through a silk batik process while addressing secondary science and art curricular topics of using both a macroscopic and microscopic lens over four class sessions. Unit objectives includes connecting previous knowledge (instruction, teaching approaches, standards, and content) from pre-service teachers’ methods courses and relating them to the integration unit, creating a small individual and larger group silk batik that represented microscopic and macroscopic scales of scientific phenomena, identify artistic and scientific concepts from their microscopic art product, and explain the
importance of science and art in the classroom based on a hands-on experience and collaboration with others.

Additional instructions for the integration unit, a course syllabus, unit pre-service teacher grading rubric, and silk batik instructions sheet were provided in Appendices C, D, and E. The most recent Science and Art-integration unit cohort involved a series of activities that ranged from individual to small group to whole classroom interactions during five sessions of a fall semester.

Session 1: Introduction

Before the Science and Art-integration unit started, a pre-survey was administered to pre-service teachers prior to the instruction of the Science and Art-integration unit. The pre-survey was used as a basis of each pre-service teacher’s confidence and self-rating levels in content knowledge, thoughts, impressions, perspectives, skill levels, and experiences with the sciences and arts. Once the pre-survey was completed, the Science and Art-integration unit began with an introduction to the unit and reviewing the rubric of what each pre-service teacher was responsible for completing by the end of the Science and Art-integration unit. Appendix C represents the five-session syllabus or schedule of the unit and what will be covered and completed by the end of each session. Appendix D is the grading rubric that was distributed to each pre-service teacher. This rubric highlighted a project portfolio that each pre-service teacher was responsible for completing by the end of the Science and Art-integration unit. The project portfolio included the projects that were to be created, a filled in group worksheet, and participation in a microteach and final group presentation.

Once the review of the unit was completed, smaller groups of pre-service science and art teachers were formed. Each group consisted of three to four team members where one to two
Science Methods’ pre-service teachers were grouped together with one to two Art Methods’ pre-service teachers (pre-determined by the unit’s instructors). This ratio reflected the enrollment trends of the secondary science and art education programs within the university. These formed teams remained intact throughout the duration of the integrated unit to allow for close-knit team collaboration and bonding.

Pre-service teachers were asked to perform a ‘microteach’ on a particular topic of focus that pertained to a variety of scientific and artistic topics. Microteach topics included: the history and chemistry of paints, surface tension, the colors of light, mixing colors, and artistic vocabulary. Pre-service teachers read pre-assigned literature that pertained to the topics of focus and taught their peers about the topic through activities and demonstrations of his or her choice. Microteaches were presented within the smaller groups to build understanding from both disciplines’ perspectives. The microteaches allowed the small groups to explore and experiment with a variety of scientific and artistic concepts, techniques, processes, and materials to develop depth of understanding of all the topics. Scientific concepts that were covered included primary and secondary colors of light, surface tension of liquids, adhesion and cohesion of liquids, and the history of paints. Artistic concepts covered in the microteaches included primary, secondary, complementary, and neutral colors through mixing of paints, understanding textures through paint application, defining composition of an image through hues, values, and saturation. After developing a prime foundation on the background of the art project ahead, the pre-service teachers were ready to immerse themselves into the next session of individual silk batik painting called the “sampler.”

**Session 2: Exploring Connections through the Sampler**
The pre-service teachers were asked to create a small, individual sampler (a 12” silk-fabric round) using the silk batik activity instructions. In the sampler, each pre-service teacher chose and portrayed a macroscopic (large view not often seen by the naked eye) random GIS satellite image of a geographic location of his or her choice (images are provided by the Methods courses’ college professors). The session introduced techniques and the process used to approach silk batik painting on the silk fabric rounds. The process included steps such as: sketching the image, resisting lines of image, drying the resist, gathering supplies and paints, application of the paints onto the fabric, setting the paint, washing, and ironing the final product. Appendix E provided an in-depth activity guide to the silk batik process; this one-page guide included: materials needed to batik, an instructional step-by-step process to silk batik painting technique, and tips during the batiking application process.

The individual sampler activity enabled the pre-service teachers to get acquainted with the art materials, supplies, and techniques used for the upcoming microscopic image project. Pre-service teachers performed the silk batik process on their own, experimented, and collaborated with peers on the creation of the art. The small groups experimented and discussed throughout the sampler activity, using artistic concepts such as: color mixing, composition, and texture (from the microteaches in the first session). See Figure 16 in Appendix F and Figure 17 in Appendix G for Individual Sampler images and figures from this session. Images were provided from Cohort 3’s pre-service teachers. Individual samplers were displayed at the end of session 2 (as displayed Figure 16 of Appendix F) and were not categorized or organized by the pre-service teacher’s discipline, which masked ability levels between science and art pre-service teachers. Not categorizing or identifying individual samplers by art or science pre-service teacher group displayed that pre-service of either discipline had equal opportunity to complete a successful individual sampler and demonstrated that any individual of any ability level of creativity or
artistic skill could produce a small silk batik sampler product. The small silk batik sampler that each art or science pre-service teacher created, prepared him or her for the main project of the unit – a larger-scale (approximately 3’ x 4’-silk batik piece), microscopic (small view not able to be seen by the naked eye) image, created by the entire group (instead of the individually made samplers).

Session 3: Small Group Silk Batik Subject Consensus

The individual sampler gave the pre-service teachers one session of experience to then apply on a larger scale and bigger silk canvas. The next task asked the pre-service teachers to use a microscopic image of their choice and captured that image onto a larger silk batik. The decision of the chosen image for the larger-scale silk batik was completely under discussion/control of each group. Each group approached the decision of the prospective microscopic image by using their prior artistic and scientific knowledge obtained from the previous two sessions through the content, vocabulary, and experience obtained through hands-on sampler and paint experimenting. Discussions for determining group microscopic images were based upon composition, color presence and mixing, textural and application processes, and scientific processes that had aesthetic appeal. Collaboration occurred in order for each group to come to a consensus and choose an image that met the needs of the unit’s rubric, could be completed within the given time constraints of the unit, and personally satisfied the group’s decision on a chosen image. These collaborative discussions helped the group reach a consensus for a microscopic image to portray in the larger silk batik, and later on influenced the group’s choice of scientific and artistic concepts that would be discussed in their final group presentation at the end of the Science and Art-integration unit.
Session 4: Finishing the Small Group Silk Batik

Once the pre-service teachers determined the image for their group’s larger silk batik, the remainder of the unit (third and fourth sessions) was utilized for finishing the larger batik. The instructor demonstrated how larger amounts (3’x4’ or 2’x4’) of silk fabric would be prepared and assembled on large wooden frames (of the same size) for batik painting. Once fabric was tight and secure to the wooden frames, the pre-service teachers were ready to begin the construction of their microscopic image portrayal on the silk (e.g. snowflake, bacteria, or plant’s xylem). During this session, the groups utilized their personal talents, skills, and prior knowledge from previous sessions to complete their larger silk batiks. Each pre-service teacher within the smaller groups contributed constructing the wooden frames, preparing the silk, drawing out images, gathering and preparing supplies, implementing the groups’ design/plan, resisting, painting, cleaning up, and finalizing the large batiks for whole class presentation/discussion. An example of a specific group’s microscopic image and their finished larger silk batik can be seen in Figure 18 of Appendix H. Figure 18 provides an example constructed by Cohort 3 representing a microscopic view of a snowflake. Microscope images can be obtained through Internet, books, or magazine resources. The original snowflake image in Appendix H can be found on-line at: https://www.flickr.com/photos/chaoticmind75/6922463361. In addition to the completion of the larger silk batik, each group was asked to fill out a group questionnaire worksheet during the sessions. This worksheet was a graphic organizer to record the group’s collaborative thoughts on the Science and Art-integration unit. The group worksheet was used to document the group’s thoughts, perspectives, ideas, and opinions regarding the unit. The group worksheet also highlighted the artistic and scientific concepts that each group believed was significant to their selected microscopic image in the larger silk batik.
Session 5: Presentation of Art & the Integration Understanding

After completion of the larger silk batiks, each group presented their finished larger silk batik to the rest of the class. Each presentation included a discussion on their microscopic image chosen, scientific concepts that revolved around the image, artistic concepts used during the creation/presentation process, and how this integration unit incorporated both disciplines into the project with a reference from a pre-assigned article. Each individual small group worked through consensus to choose scientific and artistic concepts, key topics, and highlights portrayed within the microscopic image in the larger silk batik. These concepts would signify key concepts that could be covered when utilizing this activity in a classroom. For example, a group who chose to portray a snowflake crystal chose the following artistic concepts to highlight from their silk batik: primary and secondary colors, visual and actual texture, balance of composition, geometric shape and organic shapes, and repetition of color. The following scientific concepts were highlighted from their snowflake silk batik: crystalline structure, atmospheric conditions, light properties, scale, and metamorphism and deposition. An example of the microscopic snowflake group’s presentation can be viewed on-line at:

https://www.youtube.com/watch?v=PbeofB5YGCg.

Each group presented their findings in a 10-minute presentation that was recorded and their final silk batik was displayed for critique, questions, and discussion. A post-survey was completed by all of the pre-service teachers to demonstrate confidence and self-rating levels in science and art content knowledge, thoughts, impressions, perspectives, artistic and scientific skill levels, and experience with science and arts upon completion of the presentations.
Chapter 4 – Methods

This chapter explains the population sample under study, how data were collected (through pre-service teacher feedback surveys, classroom observations, group questionnaires, group presentations, and peer interviews), and how data were analyzed (in quantitative and qualitative research methods).

Population Sample

The research study presented here focused on three consecutive years of the Science and Art-integration unit during fall semesters. Over the course of three-years, the sample size of all three cohorts consisted of 52 pre-service teachers (with 16-20 pre-service teachers in each cohort) from the Science and Art Methods’ courses of a western university in the United States. The years were distinguished as Cohort 1 (Fall 2012), Cohort 2 (Fall 2013), and Cohort 3 (Fall 2014). The Science and Art Methods courses consisted of undergraduate and graduate pre-service teachers of a science (physics, chemistry, earth science, geology, or biology) or art discipline. Each cohort had an uneven balance of science and art education pre-service teachers. The area of study or discipline was the only form of demographics that was collected from each cohort. A breakdown of the number of science and art pre-service teachers that participated in the Science and Art-integration unit for each cohort can be found in Table 1.
Table 1. *Pre-Service Teacher Cohort Breakdown*

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<tr>
<td>Art Education</td>
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<td>5</td>
<td>9</td>
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<tr>
<td>Science Education</td>
<td>9</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>16</td>
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Scientific and artistic ability levels were not quantified or identified from the pre-service teacher participants in any of the cohorts, however the level of artistic skill, scientific skill, experience level with scientific mediums, and experience level with artistic mediums were asked to be identified in a pre- and post- survey. Not analyzing the pre-service teacher participants by ability level allowed for all participants to receive the same instructions, collaborate with one another, and demonstrate that silk batik products were not critiqued or discussed based on artistic ability, but to demonstrate success of a completed product. The participants in all three cohorts were given the same pre- and post- surveys to obtain quantitative and qualitative data.

*Data Collection*

Research was conducted through a mixed methods approach to gain quantitative and qualitative data. The researcher obtained the qualitative and ethnographic insight as a participant and observer in the study. A variety of methods were used to obtain quantitative and qualitative data for this case study. Data sources include: 1) Instructor provided pre- and post- Likert survey of pre-service teachers’ perceptions of knowledge confidence and self-rating level towards the Science and Art-integration for all three cohort years, 2) Researcher/participant collected
classroom ethnographic observation(s) during the Science and Art-integration unit sessions/presentations from only Cohort 3, and 3) Researcher/participant conducted peer interviews to gain ethnographic/qualitative insight on participant’s perspectives of the integration unit solely from Cohort 3.

The researcher used previously collected quantitative data from previous cohorts’ (Year 1 and 2) science and art integration units and gathered data from the current cohort’s Science and Art-integration unit (Year 3) that was provided through a survey preceding and following the Science and Art-integration unit. From an extension of Dambekalns (2005) and Medina-Jerez et al. (2012), the researcher extended her work by collecting ethnographic, observational, qualitative data as a participant/observer. The ethnographic, qualitative data collected strived to understand how the integration activity influenced her peers (pre-service teachers) to utilize other disciplines into their core-content curriculum, supplies the needs of the teachers, strengthens science and art, as well as how science and art educators are using each other to create a combined unit. All data collected from the three cohorts through pre- and post- surveys, session observations and presentations, and interviews. All data were anonymized upon completion of data analysis.

Pre-Service Teacher Surveys

Surveys were administered to collect quantitative information on the perceived confidence and self-rating level of knowledge of science and art compatibility. Each year (for three years), a pre- and post- survey was completed by each participating pre-service teacher individually of each cohort to demonstrate self-rated confidence in science and art content knowledge, thoughts, impressions, and perspectives. The survey contained questions that measured individual pre-service teacher perception of how the two disciplines could be
integrated together. See Appendix I for a detailed example of the pre-service survey sheet used. In addition to perceived confidence and self-rating levels of knowledge in science and art, personal questions were asked for each pre-service teacher to identify the level of artistic and scientific skills brought to this specific project, his or her previous experience levels working with scientific or artistic mediums, and his or her level of previous experience working with other pre-service teachers of any other discipline. Following the Likert-scale questions, ethnographic/qualitative data were collected through open-ended questions. The open-ended questions asked each pre-service teacher to provide further insight into highlights, challenges, and his or her perspectives/experiences before and after the integration unit. The open-ended questions allowed each pre-service teacher to express his or her thoughts and opinions of the Science and Art-integration, how the two are incorporated together, and personal teaching perspectives on the integration unit itself.

**Classroom Observations**

Only for the current year’s cohort (Cohort 3 – 2014), the researcher/participant collected ethnographic/qualitative observational data from her group of peers in order to understand how the activity personally motivated or caused resistance for incorporation of other disciplines into the participant’s core-content curriculum, supplied the needs of the teachers, strengthened science and art together, and how science and art educators are partnering to create a combined unit. The researcher/participant took notes during small group time on processes, challenges, successes, group interactions, and individual/group thoughts. The main purpose of classroom observation was to observe pre-service teachers’ reactions and verbal perspectives towards the Science and Art-integration unit. Classroom observations were only conducted during the course’s scheduled time frame.
Group Questionnaire

Within each cohort, each small group was asked to fill in a group discussion sheet (worksheet) that helped organize and address the groups’ collaborative views on the integration unit. This worksheet was filled in during the working sessions and after the Science and Art-integration unit was completed. The researcher/participant’s small group discussion worksheet was analyzed for this study (the snowflake group). See Appendix J for the set of questions that pre-service teachers were asked to answer in their small groups.

Group Presentations

Only for the current year’s cohort (2014), the researcher/participant collected qualitative data from each group’s experiences from video recordings made during the final presentations at the conclusion of the integration unit. Each group presented their large silk batik and included: a discussion on the microscopic image chosen, scientific concepts that revolved around the image, artistic concepts used during the creation/presentation process, and how this integration unit incorporates both disciplines into the project with a reference from a pre-assigned article. The group presentations were video recorded the day of presenting and all of the presentations were transcribed prior to data analysis.

Peer Interviews

The researcher’s personal group members (snowflake group) participated in interviews that were conducted by the researcher/participant (herself), in order for her to gain an in-depth perspective on her team members’ experiences of the unit. Personal perspectives from both content fields were identified. The interviews were conducted in a public place and lasted for approximately 20-minutes. The questions focused on emotional feelings and perceptions before, during, and after the Science and Art-integration unit, including asking whether they would use
concepts of this integration unit in their own future classrooms. Please see Appendix K for the questionnaire asked during peer interviews.

Data Analysis

Pre- and post- Science and Art-integration survey data (nineteen questions) contained 52 individual responses over the course of three years. The years were distinguished as Cohort 1 (Year 2012), Cohort 2 (2013), and Cohort 3 (2014). There were a total of nineteen questions presented in the pre- and post- survey. The first eight questions were used for a quantitative analysis that focused on perceived confidence and self-rated knowledge levels in science and art content progression, materials, thoughts, impressions, and perspectives. The next five questions captured personal information regarding individual skill and experience levels for the pre-service teachers in artistic and scientific mediums and skills, as well as prior experience working with other pre-service teachers of any discipline. These five questions asked the pre-service teachers to identify his or her individual scientific and artistic skill levels, experience levels with scientific and artistic mediums, and level of prior experience in collaborative work with other pre-service teachers from any other discipline with respect to the Science and Art-integration unit. The remaining six questions were used for an ethnographic/qualitative analysis that requested individual responses in regards to challenges and benefits of the integration, similarities between the two disciplines, and the terms collaboration and partnership.

Quantitative Methods

The quantitative portion was divided into two sections: 1) confidence in art, science, and interdisciplinary teaching knowledge and 2) skill and experience levels with art, science, and working with other pre-service teachers. For the pre- and post- Science and Art-integration survey data, a mean was calculated with standard deviation for each confidence level in knowledge question (questions 1-8) and personal question (questions 9-13) answered by
participants over a three-year period. Each pre-survey mean was compared to each post-survey mean for each cohort, as well as all three cohorts together to analyze change with respect to the pre-service teacher participation in science and art-integration unit. Paired sample t-test comparisons were determined for statistical significance for a 95% confidence interval (p < 0.05) between the pre- and post-survey means for each question of each year.

**Qualitative Methods**

For this specific study, three of the six open-ended questions were analyzed (questions 14-16 in the survey). These three questions asked the pre-service teachers to identify any benefits and challenges to a science and art-integration unit and to identify similar skills that both scientists and artists practice. During the open-ended survey questions, the pre-service teachers answered the following questions: what were the benefits of a Science and Art-integration unit, what were the challenges to a Science and Art-integrated unit, and how do artists and scientists practice similar skills? Three of the six qualitative questions (14, 15, & 16) were analyzed by highlighting and color-coding specific common themes (Creswell, 2003) and concepts over the three-consecutive years. See Figure 1 for a key of the common themes and concepts found during analysis. Each theme/concept was counted for each individual year within a pre- and post-survey cohort. Once all themes were identified, highlighted, and counted, the most common themes were determined over the three consecutive years. Alongside the three-year ethnographic/qualitative themes that were gathered from the data, the common themes and concepts were compared to the observations, interviews, and presentations that was obtained from the sessions and presentations of the current year’s cohort to determine cohesiveness, connections, and support.
<table>
<thead>
<tr>
<th>Most Common Themes and Concepts Color Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Questions #14-16 Key</td>
</tr>
<tr>
<td>Creativity</td>
</tr>
<tr>
<td>Using Visual Tools/Representations</td>
</tr>
<tr>
<td>Engagement</td>
</tr>
<tr>
<td>Collaboration &amp; Working Together with Other Teachers in a School</td>
</tr>
<tr>
<td>Alternative Learning Styles/Strategies</td>
</tr>
<tr>
<td>Interdisciplinary Learning</td>
</tr>
<tr>
<td>Making Real World Connections</td>
</tr>
<tr>
<td>Observational Skills</td>
</tr>
<tr>
<td>Problem solving by Similar Methods</td>
</tr>
<tr>
<td>Not Having A Strong Artistic Background</td>
</tr>
<tr>
<td>Not Having A Strong Scientific Background</td>
</tr>
<tr>
<td>Time Commitment</td>
</tr>
</tbody>
</table>

*Figure 1. Qualitative Common Themes.*
Chapter 5 – Findings

This chapter explains the quantitative and qualitative findings and results conducted from the science and art-integration unit research.

Quantitative Results

Within each cohort, a mean was calculated for each question of the pre- and post- survey. The averages to each question were analyzed from pre- survey to post- survey results. In a pre- to post- survey examination, there was a general increase in confidence levels in science and art content and interdisciplinary teaching strategies knowledge for all three cohorts. Of the eight questions that were surveyed over the course of three years, 100% of post-survey means increased from the pre- survey after completion of the Science and Art-integration unit. All three cohorts demonstrated increased confidence in knowledge levels (cohort means) for the following questions: ways to engage learners with interdisciplinary connections, usefulness of satellite imaging, ways to develop interdisciplinary connection units, use of visual literacy made by both artists and scientists, implementation of instructional activities for visual learners, knowledge of physical principles of mediums, using scientific images as an aesthetic tool, and ways to integrate science and art.

Paired-sample t-tests were conducted on the individual pre- and post- survey questions for each cohort. All three cohorts showed 95% significance (p<0.05) in seven out of the eight quantitative questions. These seven questions demonstrated an increase in confidence and self-rating in knowledge within the Science and Art -integration unit. Questions 1, 2, 3, 4, 6, 7, and 8 demonstrated significant increase in perceived confidence self- rating in knowledge from the pre- and post- survey among all three cohorts included: levels in finding ways to engage learners with an interdisciplinary connection, the usefulness of satellite imaging as a context for classroom science learning, ways to develop an interdisciplinary unit, the use of visual literacy made by
both artists and scientists, the physical properties of mediums, and using satellite imaging as an aesthetic tool. (See Table 2 & Table 5 in Appendix L for a full statistical summary.)

Table 2. Summary of Confidence in Art, Science, and Interdisciplinary Teaching Knowledge Levels

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre-Survey Mean (SD)</th>
<th>Post-Survey Mean (SD)</th>
<th>P-value</th>
<th>Pre-Survey Mean (SD)</th>
<th>Post-Survey Mean (SD)</th>
<th>P-value</th>
<th>Pre-Survey Mean (SD)</th>
<th>Post-Survey Mean (SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.63 (1.81)</td>
<td>8.63 (0.87)</td>
<td>0.024</td>
<td>6.24 (1.31)</td>
<td>8.00 (1.08)</td>
<td>0.030</td>
<td>6.69 (0.91)</td>
<td>8.38 (1.33)</td>
<td>0.0024</td>
</tr>
<tr>
<td>2</td>
<td>4.79 (2.35)</td>
<td>8.63 (1.09)</td>
<td>0.00037</td>
<td>4.47 (2.81)</td>
<td>7.65 (1.45)</td>
<td>0.00062</td>
<td>4.27 (1.72)</td>
<td>7.15 (1.92)</td>
<td>0.038</td>
</tr>
<tr>
<td>3</td>
<td>6.05 (1.88)</td>
<td>8.47 (0.99)</td>
<td>0.00076</td>
<td>6.00 (1.50)</td>
<td>8.00 (1.12)</td>
<td>0.00037</td>
<td>6.69 (1.75)</td>
<td>8.15 (1.55)</td>
<td>0.028</td>
</tr>
<tr>
<td>4</td>
<td>6.42 (2.32)</td>
<td>9.05 (0.76)</td>
<td>0.0096</td>
<td>6.12 (2.72)</td>
<td>7.94 (1.43)</td>
<td>0.0063</td>
<td>6.46 (1.91)</td>
<td>8.38 (1.55)</td>
<td>0.018</td>
</tr>
<tr>
<td>5</td>
<td>7.26 (1.58)</td>
<td>8.89 (0.79)</td>
<td>0.047</td>
<td>7.59 (1.75)</td>
<td>8.11 (1.32)</td>
<td>0.025</td>
<td>8.00 (1.18)</td>
<td>8.77 (0.89)</td>
<td>0.018</td>
</tr>
<tr>
<td>6</td>
<td>6.16 (2.32)</td>
<td>8.63 (1.13)</td>
<td>0.0032</td>
<td>6.88 (2.19)</td>
<td>8.65 (1.08)</td>
<td>0.0033</td>
<td>6.38 (1.98)</td>
<td>7.38 (1.69)</td>
<td>0.047</td>
</tr>
<tr>
<td>7</td>
<td>5.42 (2.52)</td>
<td>9.00 (0.86)</td>
<td>0.0007</td>
<td>6.82 (1.82)</td>
<td>8.82 (1.04)</td>
<td>0.0045</td>
<td>5.05 (1.82)</td>
<td>9.51 (0.77)</td>
<td>0.013</td>
</tr>
<tr>
<td>8</td>
<td>5.53 (1.96)</td>
<td>8.95 (0.94)</td>
<td>0.0076</td>
<td>5.82 (1.82)</td>
<td>8.35 (1.28)</td>
<td>0.0045</td>
<td>6.54 (1.82)</td>
<td>8.23 (1.31)</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Of the eight questions asked, there was one question that demonstrated significance in two of the three cohorts (Cohorts 1 and 3). Question 5 asked the pre-service teachers to indicate the level of confidence in knowledge of implementation of instructional activities for visual learners in a teacher’s discipline.

Figures 2, 3, and 4 represent each individual cohort year’s mean in confidence and self-rating of knowledge levels amongst the survey questions asked based upon pre- and post- survey results. See Figure 5 for cumulative graph representing the results of all three-cohort means for all eight questions of pre-survey and post-survey.
Figure 2. Cohort 1 Confidence in Art, Science, & Interdisciplinary Teaching Knowledge

Figure 3. Cohort 2 Confidence in Art, Science, & Interdisciplinary Teaching Knowledge
Questions 9-13 asked each pre-service teacher to identify his or her individual scientific and artistic skill levels, experience levels with scientific or artistic mediums, and level of prior experience in collaborative work with other pre-service teachers from any other discipline with respect to the Science and Art-integration unit. Even though these five questions were not considered towards the quantitative analysis, there was relevance from a pre- to post-survey standpoint. For questions 9, 10, and 13 (level of artistic skills brought to the project, level of
scientific skills brought to the project, and level of previous experience with other pre-service teachers in any other discipline), there was an increase in cohort means from pre- to post- survey for all three cohorts. Questions 11 and 12 (level of previous experiences with artistic and scientific mediums) had increased post- survey cohort means for two of the three years. However when analyzing significance between pre- and post- survey cohort means for each question, questions 9, 10, 12, and 13 only served significance for only one year. Refer to Table 3 for a summary of confidence in skills and experience levels. Please refer to Table 5 of Appendix L for a full statistical summary.
Table 3. *Summary of Confidence in Artistic, Scientific and Experience Levels*

<table>
<thead>
<tr>
<th>Question</th>
<th>Cohort 1 – 2012</th>
<th>Post-Survey Mean (SD)</th>
<th>p-value</th>
<th>Cohort 2 – 2013</th>
<th>Post-Survey Mean (SD)</th>
<th>p-value</th>
<th>Cohort 3 – 2014</th>
<th>Post-Survey Mean (SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>6.63</td>
<td>7.89</td>
<td>0.13</td>
<td>6.94</td>
<td>0.85</td>
<td>7.15</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.74)</td>
<td>(2.36)</td>
<td></td>
<td>(2.62)</td>
<td>(3.55)</td>
<td>(2.25)</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5.89</td>
<td>8.00</td>
<td>0.012</td>
<td>6.88</td>
<td>7.35</td>
<td>0.754</td>
<td>8.15</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.85)</td>
<td>(1.78)</td>
<td></td>
<td>(2.37)</td>
<td>(2.27)</td>
<td>(1.50)</td>
<td>(1.70)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>7.32</td>
<td>7.79</td>
<td>0.55</td>
<td>6.06</td>
<td>6.65</td>
<td>0.685</td>
<td>6.54</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.43)</td>
<td>(2.24)</td>
<td></td>
<td>(2.92)</td>
<td>(3.01)</td>
<td>(2.88)</td>
<td>(2.87)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>6.32</td>
<td>7.74</td>
<td>0.23</td>
<td>6.94</td>
<td>7.24</td>
<td>0.777</td>
<td>7.69</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.47)</td>
<td>(2.02)</td>
<td></td>
<td>(2.49)</td>
<td>(2.34)</td>
<td>(1.42)</td>
<td>(1.54)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>5.05</td>
<td>5.95</td>
<td>0.014</td>
<td>3.88</td>
<td>6.29</td>
<td>0.569</td>
<td>7.08</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.58)</td>
<td>(2.48)</td>
<td></td>
<td>(2.16)</td>
<td>(2.32)</td>
<td>(2.70)</td>
<td>(1.86)</td>
<td>66</td>
<td></td>
</tr>
</tbody>
</table>
See Figures 6, 7, and 8 that represent each individual cohort’s mean in skills and experience levels amongst the survey questions asked based upon pre- and post-survey results. See Figure 9 for cumulative graph representing the results of all three-cohort means for all eight questions of pre-survey and post-survey.

Figure 6. Cohort 1 Confidence in Artistic, Scientific, Collaborative Skills and Experience Levels

Figure 7. Cohort 2 Confidence in Artistic, Scientific, Collaborative Skills and Experience Levels
Figure 8. Cohort 3 Confidence in Artistic, Scientific, Collaborative Skills and Experience Levels

Figure 9. Cumulative Confidence in Artistic, Scientific, Collaborative Skills and Experience Levels

Qualitative Results

The remaining six open-ended questions (questions 14-19) from the pre and post-survey allowed pre-service teachers the ability to freely voice their opinions, thoughts, and perspectives regarding the Science and Art-integration unit. Three of the six open-ended questions (questions
14-16) were analyzed for this study highlight common themes amongst the pre-service teacher responses. Common themes that arose from the open-ended responses included: creativity, using visual tools and representations, engagement, collaboration and teamwork between teachers in a school, alternative learning strategies and styles, interdisciplinary learning, making real-world connections, observational skills, problem solving by similar methods, not having a strong artistic background and skills, not having a strong artistic background and skills, and time commitment.

The first question asked the pre-service teachers to provide benefits to a Science and Art-integrated unit. There was a general increase in overall awareness of benefits of a Science and Art-integrated unit. The most common themes that the pre-service teachers cited over the three years in a pre-survey response included: interdisciplinary learning, alternative learning styles and strategies, real-world connections, and collaboration and working together with other teachers in a school. From a pre-survey to post-survey standpoint, there were two things that stood out within the data: 1) pre-service teachers transitioned from interdisciplinary learning as a leading benefit in the pre-survey to highlighting a variety of benefits after the unit (such as: engagement, alternative learning strategies, working together, as well as interdisciplinary learning); and 2) pre-service teachers did not acknowledge that problem-solving or making real-world connections were not benefits. This second stand out point contradicted what was originally highlighted as benefits from the literature read. See Figure 10 for individual cohort highlighted benefits from a pre- and post-survey perspective. Figure 11 represents a cumulative summary of benefits that Cohorts 1, 2, and 3 highlighted together.
Figure 10. Common Benefits to a Science and Art-Integrated Unit

Figure 11. Cumulative Summary of Common Benefits to a Science & Art-Integrated Unit

The second question asked to provide challenges that can occur with a Science and Art-integrated unit. From a pre-survey to post-survey analysis, there was a general decrease of highlighted challenges. From the pre-survey, most common themes taken from the three years
included: interdisciplinary learning, not having a strong scientific background and skills, not having a strong artistic background and skills, and time commitment. Post-survey themes included: interdisciplinary learning, collaboration and working together with other teachers in a school, and not having a strong scientific background and skills. See Figure 12 individual cohort highlighted common challenges from a pre- and post- survey perspective. Figure 3 represents a cumulative summary of all common challenges that Cohorts 1, 2, and 3 highlighted together.

**Figure 12.** Common Challenges to a Science and Art-Integrated Unit
Figure 13. Cumulative Summary of Common Challenges to a Science & Art-Integrated Unit

The last question analyzed the responses on how the pre-service teachers thought scientists and artists practice similar skills. From a pre-survey to post-survey analysis, there was a general increase in awareness of similar skills that are shared between scientists and artists. Pre-survey responses that were most common were: problem solving through similar methods, observation skills, and using visual tools and representations. Upon completion of the Science and Art-integrated unit, the pre-service teachers responded with problem solving by similar methods, observational skills, and using visual tools and representations in the post-survey. See Figure 14 individual cohort highlighted common skills that are practiced by both artists and scientists from a pre- and post- survey perspective. Figure 15 represents a cumulative summary of all common skills that are practiced by both artists and scientists that Cohorts 1, 2, and 3 highlighted together.
Each cohort presented their larger silk batiks and discussed their experiences and synthesis of the unit. However, Cohort 3’s presentations were transcribed and compared to determine if there were overlapping topics in conjunction with the qualitative themes found in
the pre- and post-survey open-ended questions. Overlapping topics that the Cohort 3’s pre-service teachers emphasized of high importance in the surveys and presentations included: benefits in problem solving by similar methods, keeping their (future K-12) students engaged, meeting needs to alternative learners, opportunities for interdisciplinary learning, and making real-world connections.

However, Cohort 3 highlighted that despite the many benefits that science and art bring to (future K-12) student learning, it can be incredibly challenging. A challenge that was brought up through presentations, interviews, and observations was time. This Science and Art-integration unit took five-sessions (two and a half weeks) to complete during a traditional 14-week fall semester. Dedicating only five sessions to this specific unit appeared to be incredibly short. A few pre-service teachers expressed a desire for more time: more time to reflect on the science component interspersed with the art and more time in creating the large silk batiks and assignments. One pre-service teacher explained, “I think a ‘weakness’ was a lack of time.” Another pre-service teacher voiced, “The unit was fun, we learned something new and unique, but we could have used more time to work on the group piece.”
Chapter 6 – Discussion

In this chapter, the questions focused on during the research are reflected upon and answered based on the data that was obtained. Based on the data collected from the Science and Art-integration unit, the Science and Art pre-service teachers demonstrated increased confidence in knowledge of the two combined disciplines, as well as emphasized that increased awareness in that the disciplines are closely linked, practice similar skills when approaching projects and problems, can complement each other in the classroom, and add meaning to the overall learning experience of any individual, and especially for our future generations. Through participation in the Science and Art-integration unit, reflection after the unit, and filling out the small group discussion worksheet, this Science and Art-integration unit helped steer pre-service teachers to the concept that the arts and sciences were not far removed from each other. Based on the data collected, research questions can be reviewed and connected to what was discovered. The research questions for the study included:

- How have pre-service secondary teachers’ perspectives about this Science and Art-Integration unit changed over a three-year period time?
- How has the batik activity influenced pre-service teachers’ perspective of science and art in their future classroom?

How have pre-service secondary teachers perspectives about this Science and Art-integration unit changed over time?

Through the past three years of science and art pre-service teachers participating in this unit, there is a general increase in three areas: 1) awareness of how the sciences and arts can be combined, 2) confidence in knowledge about integrating the art and science together, and 3) increase in skills and experiences to utilize in their future classrooms. This unit specifically opens eyes and minds to new ways that pre-service teachers can use both disciplines in the same
classroom. These pre-service teachers gained confidence in knowledge about how to integrate the sciences and arts through a specific activity, how to engage their future (future K-12) students with interdisciplinary connection, ways to develop an interdisciplinary unit through science and art, how to develop understanding that scientific images can be used as tools, and way to understand the usefulness of satellite and microscopic/macroscopic images as a context for classroom learning. Through this unit, pre-service teachers have collected information for their personal teaching toolboxes to enhance their future classrooms that are engaging, different, and meaningful for their (future K-12) students.

In addition to gaining confidence in knowledge about integrating the sciences and arts, pre-service teachers’ perspectives, skills, and experience levels shifted. Originally, it was addressed in the pre- and post- surveys that not having an artistic or scientific background would be a challenge during this unit. However, following the unit, post-survey results supported that not having these backgrounds were not a challenge in the end and could be overcome and worked through. In addition to this perspective change, pre-service teachers’ increased their skillset with the arts and sciences, their experiences with artistic and scientific mediums, and their experiences working with other pre-service teachers from other disciplines.

Artistic and scientific skill levels that were brought to the Science and Art-integration unit should not have changed for each pre-service teacher, however, over the course of the 5-session unit, there is a significant increase in cohort means that the unit helped gain artistic and scientific skills, experiences with artistic and scientific mediums, and experiences working with other pre-service teachers from other disciplines. Even though not all years pre- to post- survey data were supported as significant, the pre-service teachers had the opportunity to have an authentic experience where their art and scientific skill set perceptions were enlightened and positively changed after the unit. The Science and Art-integration unit builds upon previous
skills and experiences the pre-service teachers have going into the unit. And in the end, provides positive outcomes and a gain in confidence in their skills and experiences for pre-service teachers to bring science and art into their future classrooms.

Through this Science and Art-integration unit, the pre-service teachers were provided with an experience on how they can use this unit in their own future classrooms as teachers, but they were able to experience how this unit would be experienced by their future students. In a sense, the pre-service teachers participated in this unit as the audience being the ones taught [by the Methods courses’ instructors]. The pre-service teachers were able to participate in the unit as one of their (future K-12) students, experience the same processes and lessons that would be used on their (future K-12) students, and witness from a pre-service teacher and (future K-12) student point of view the skills and standards that are addressed during this unit.

A major component of this integration unit was the development of skills. Both pre-service teachers and (future K-12) students are learning how to use materials and equipment effectively, while learning how to perform or execute the artistic medium (of silk batiking). Once these skills are developed, both pre-service teachers and (future K-12 students) are able to relate the process of creating art with the science content knowledge. Through this Science and Art-integration unit, the skills that are acquired from a pre-service teacher and a (future K-12) student and connections to NGSS and Wyoming State Fine and Preforming Arts Content and Performance Standards. In Appendix M, there is a table summary of the skills that the pre-service teachers and (future K-12) students work on during the Science and Art-integration unit based on the higher thinking skills that are developed through a Bloom’s Taxonomy model (Utilizing Bloom’s Taxonomy. n.d.), as well as how this integration unit aligns with standards that teachers are required to cover in their classrooms. The table summary is great resource pre-service teachers can use to understand how the Science and Art-integration unit has affected
them (perspectives, skills, and experiences), while understanding what their (future K-12) students are going to learn, develop, and experience.

_How has the silk batik activity influenced teachers’ perspectives of science and art in the classroom?_

The objectives of this unit were to allow the pre-service teachers to recognize the idea of other disciplines being incorporated into their classroom, to recognize challenges and benefits of interdisciplinary learning, and to understand how collaboration and support of others in your school can be used in interdisciplinary units. Upon the completion of the Science and Art-integration unit, pre-service teachers were able to highlight challenges, benefits, and similarities of science and art being presented in the same classroom.

**Challenges.** Pre-service teachers were able to recognize how this integration unit can be incredibly challenging. A common challenge expressed was of collaboration and working together. One pre-service teacher responded in the post-survey, “Collaboration, open-mindedness, and willingness to adapt to uncomfortable academic disciplines are a challenge.” While another pre-service teacher added in their post-survey, “It would be challenging to find another [art] teacher willing to work with in the future.” Also, the idea of interdisciplinary learning when educators are knowledgeable only in one content area can be incredibly intimidating. Pre-service teachers noted that, one discipline was focused on more than the other and that the challenge was to maintain balance. As one pre-service teacher explained, “It was difficult to keep the science topics going during the artistic creative process.” Another pre-service added, “The challenge is creating a balance so one does not power over the other.” Also, when seeking support, resources, or experts of other disciplines, there needs to be collaboration and willingness from both educators. Pre-service teachers expressed worry that other teachers
may be unwilling to help and the responsibility for the unit would be forced onto one person, which seems stressful.

**Benefits.** Despite the feelings of an imbalanced unit from the pre-service teachers, the Science and Art-integration unit was overwhelmingly successful. Pre-service teachers highlighted that this unit benefits (future K-12) student-learning by providing engagement, allowing for opportunities of fun and creativity, meeting needs of visual and other alternative learning styles within (future K-12) students, and providing opportunities to connect concepts and simultaneously teach differing fields.

The arts and sciences are being taught in conjunction through creative, engaging, and connective means. Through this research and the support of previous literature, pre-service teachers accepted the idea of interdisciplinary learning by combining multiple disciplines into the same classroom. Pre-service teachers realized these two disciplines could be fun and engaging for (future K-12) student learning. One pre-service teacher expressed from the current cohort, “[it’s] a way to use science and art concepts to create lessons that are creative, engaging for (future K-12) students that are academically driven or who are not creative, and can help them understand the world around them.” Through the Science and Art-integration unit, pre-service teachers were able to recognize that the arts can be utilized as visual tools and representations to communicate scientific concepts and help (future K-12) students better understand them. By incorporating these two disciplines into the classroom, the possibilities are endless and a series of skills can be developed, such as: problem solving, processing, analysis, and synthesizing of information, concepts, and processes. The Science and Art-integration unit developed awareness of interdisciplinary learning for pre-service teachers by providing examples or ideas of how the arts can be added into the STEM framework. One group stated, “You can present science terms in an image, while explaining these concepts to your (future K-12) students in artistic terms.”
This particular group utilized a microscopic image of a plant cell. It was explained that this large silk batik project of representing a plant cell enabled problem-based learning. The participants explained,

You have a lesson on the parts of a plant cell, you are not just focusing on making art, but they are learning about the plant and how the plant takes in nutrients. (future K-12) students can portray [the] consumption process, [and] show it in the art. You are re-creating a specific scientific process that you talk about and are not just looking at that process in a diagram in a book.

**Similarities.** The pre-service teachers discovered that both scientists and artists go through the same processes in order to solve problems or go about approaching projects. Both scientists and artists require observational skills in order to examine their artwork or a specimen under study. In addition to using similar problem solving methods and observational skills, both artists and scientists use and embrace the creative side of their mind. One group presentation highlighted,

This activity sparks creativity. STEAM can lead to higher order thinking, new orders of thinking that have not been thought of yet. That is how we advance – creativity. We are not going to advance if we keep going over the same stuff. So, by having creativity, (future K-12) students see things in new ways and that is a great way for (future K-12) students to come up with new ideas.
Chapter 7 – Conclusion & Recommendations

This chapter explains what was supported and determined through the research under study. Implications, limitations, and recommendations are highlighted. Incorporating the sciences and the arts together through an interdisciplinary approach, allows pre-service teachers of one discipline to be influenced and inspired to use the other discipline in his or her future classroom. When science and art are combined, they complement each other while providing engaging, fun, and meaningful learning experiences. This Science and Art-integration unit helped pre-service teachers to recognize that these two disciplines utilize the same processes, methods, and skills, enhance observational skills, help broaden understanding of a variety of curriculum and concepts, identify meaning and real-world connections, and develop skills that are incredibly important to the ‘21st century society’ our country is living in. Integrating artistic learning strategies into the science classroom makes the subject less intimidating, thus, bridging making learning meaningful to a variety of styled learners. Providing artistic entry points into scientific lessons, promotes opportunities for hands-on participation, inquiry, testing individual questions and hypotheses, collaboration with others, and enhanced creativity.

Implications

Pre-service teachers are introduced to interdisciplinary learning and inspired through a hands-on example of how the sciences and arts can be taught simultaneously before entering the classroom. If you provide examples of ways that interdisciplinary learning can occur, this inspires teachers more to try new things in their own classrooms.

The role for pre-service teachers or educators in the classroom is to share information of various fields with future generations and inspire them to continue to strive for deeper understanding in those fields. This inspiration to dive deeper into understanding through STEM
should be a main mission for the United States. In order for this country to be at the top of advancement in technology and innovation, it needs to create that inspiration with art as well. By influencing perspectives of pre-service teachers in a collaboration of science and art, before they embark on their teaching careers in schools, this provides a beginning step for STEM to turn into STEAM.

That inspiration is derived from creativity (derived from science and art taught side-by-side), which allows for that advancement to occur: through the process of trial and error, (future K-12) students create experiment, fail, succeed, and try again. This study represented how art can be added into a science curriculum. However, there should be more research done on how the arts are adding science into their curriculum and classroom, to make sure that this interdisciplinary approach is being taught from both disciplines. Our country’s advancement to the top of the STEM fields can only happen if the arts are included in this mission, a STEAM mission.

Limitations

This integrated science and art collaboration for pre-service teachers provided insight for increased confidence in knowledge of the science and art disciplines. However, this integration unit only covered a grain-sized portion of interdisciplinary learning between the two fields. A few constraints encompassed this study.

This particular research was only looking at one example of a Science and Art-integration for pre-service teachers: pre-service teachers were asked to design and paint pieces of art onto silk batik canvas to address secondary science curriculum topics through the macroscopic and
then the microscopic lens. Only silk batik and paint were used; incorporating more materials (such as dyes or inks) would allow for more exploration.

Groups only worked on one microscopic image, however, if individuals could move around and work on different projects (of other topics), then each group could expand the variety of images that are experienced. Different projects with differing topics could provide pre-service teachers with other ideas beyond silk batik and using microscopic imaging.

The Science and Art-integration unit only dedicated 5-sessions worth of time; it seemed relatively short to complete projects in a timely manner and provide opportunities to fully reflect on how science and art can be combined together. Despite the time constraint felt from the pre-service teachers, the Science and Art-integration takes up 5-sessions of the 16-week Methods courses. These 5-sessions dedicated to the Science and Art-integration unit takes up a third of the course, which provides a significant impact of focus on science and art being integrated into the classroom. However, one more session would provide additional time for reflection for how the sciences and arts can be successfully integrated together.

Observations and ethnographic data were only collected for Cohort 3. Personal experiences and perspectives of detailed breadth and richness were obtained from one cohort and not all three cohorts. This could mean that details that were not captured through the pre- and post- survey had been completely discarded and skew the experience for Cohorts 1 and 2.

Recommendations

The Science and Art-integrated unit provides a great beginning to engage pre-service teachers in considering different ways to teach the 21st century skills needed in society. Through class discussion and the survey, it was pointed out that STEAM cannot be implemented into
classrooms or schools instantly. “Arts + STEM in schools” is not an overnight thing. Similar to any other standard, process, or method in any organization or school, new ideas and processes need to be supported and assisted for growth. Science and Art-integration units in educational methods courses at universities are a beneficial start for new educators and provide a professional development springboard to having STEAM become part of school curriculum. These opportunities provide inspiration and instant evidence that science and art can be taught in conjunction together in the same classroom. Future recommendations for this study are to:

- Lengthen the Science and Art-integration unit to provide teachers opportunities to gain richness and breadth from this specific Science and Art-integration unit
- Offering other science and art subfields, mediums, and projects to be explored within the Science and Art-Integration unit
- Create a specific Science and Art-Integration course for the interdisciplinary classroom
- Research and compare how education departments in other universities across the country are addressing science and art in the same classroom with pre-service teachers.
- This paper focused on how an infusion of visual art can influence a science lesson. Extended studies should be undertaken to gain deeper understanding and knowledge of how the sciences can influence the arts. With a goal of defining a co-equal approach to teaching science and art in an interdisciplinary classroom.
References


Wyoming Videos. (2014). *U-cross pollination experiement at Saturday U: At the root of balance* [Video file]. Retrieved from https://www.youtube.com/watch?v=u72f62YZ2Qg


Appendix A

**Next Generation Science Standards, Wyoming State Fine & Performing Arts, and Wyoming State Science Standards**

<table>
<thead>
<tr>
<th>Curriculum Standards</th>
<th>Example For Grades 9-11</th>
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<tbody>
<tr>
<td><strong>Next Generation Science Standards</strong></td>
<td><strong>Emphasizing Overall Performance Expectation:</strong></td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>(Earth’s Systems emphasized)</td>
</tr>
<tr>
<td>K-12 Science Curriculum Instruction &amp; Assessment</td>
<td>HS-ESS2-1: Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.</td>
</tr>
<tr>
<td>Transfere to Scientific &amp; Engineering Practices</td>
<td>Developing &amp; Using Models: Develop a model based on evidence to illustrate the relationships between systems or between components of a system.</td>
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<tr>
<td>Behaviors &amp; Skills Through Inquiry</td>
<td>Stability &amp; Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</td>
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<tr>
<td>Cross-Cutting Concepts</td>
<td></td>
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<tr>
<td>Patterns; Cause &amp; Effect; Scale, Proportion, and Quantity; Systems &amp; System Models, Energy &amp; Matter in Systems; Structure &amp; Function; Stability &amp; Change of Systems</td>
<td></td>
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<tr>
<td>Science</td>
<td></td>
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<tr>
<td>Concepts &amp; Processes: Science is a dynamic process; concepts and processes in life systems, earth and space systems, and physical systems are best learned through inquiry and investigation. Students develop an understanding of scientific content through inquiry within the context of these unifying concepts and processes: systems, classification, order, and organization; evidence, models, and explanations; change, constancy, and measurement; and form and function.</td>
<td>SC 11.1.7: (Earth &amp; Space Systems emphasized) Describe the Earth as a closed system and demonstrate a conceptual understanding of the following systems: geosphere, hydrosphere, atmosphere, and biosphere. Explain the role of energy in each of these systems, such as weather patterns, global climate, weathering, and plate tectonics.</td>
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<tr>
<td>Science as Inquiry: Students demonstrate knowledge, skills, and habits of mind necessary to safely perform scientific inquiry. Inquiry is the foundation for the development of content, teaching students the use of processes of science that enable them to construct and develop their own knowledge. Inquiry requires appropriate field, classroom, and laboratory experiences with suitable facilities and equipment.</td>
<td>SC 11.2.2: Students use inquiry to conduct scientific investigations. Pose problems and identify questions and concepts to design and conduct an investigation. Collect, organize, analyze, and appropriately represent data. Give priority to evidence in drawing conclusions and making connections to scientific concepts. Clearly and accurately communicate the result of the investigation.</td>
</tr>
<tr>
<td>History &amp; Nature of Science in Personal &amp; Social Decisions: Students recognize the nature of science, its history, and its connections to personal, social, economic, and political decisions. Historically, scientific events have had significant impacts on our cultural heritage.</td>
<td>SC 11.3.2: Students examine how scientific information is used to make decisions. Interdisciplinary connections of the sciences and connection to other subject areas and career opportunities. The role of science in solving personal, local, national, and global problems. The origins, limitations, and conservation of natural resources, including Wyoming examples.</td>
</tr>
<tr>
<td>Fine &amp; Performing Arts (Visual Arts emphasized)</td>
<td><strong>Creative Expression Through Production:</strong> Students create, perform, exhibit, or participate in the arts.</td>
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<td></td>
<td><strong>Aesthetic Perception:</strong> Students respond to, analyze, and make informed judgments about the arts.</td>
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<td></td>
<td><strong>Historical &amp; Cultural Content:</strong> Students demonstrate an understanding of the arts in relation to history, cultures, and contemporary society.</td>
</tr>
<tr>
<td></td>
<td><strong>Artistic Connections:</strong> Students demonstrate an understanding of the arts in relation to history, cultures, and contemporary society.</td>
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</tbody>
</table>

Table 4 Comparisons of the Next Generation Science Standards and the Wyoming State Fine & Performing Arts and Wyoming State Science Standards
Appendix B

EDCI5250 Advanced Topics in Pedagogy/Secondary Science

Methods I Course Syllabus

Fall 2014

Instructors: Debbie French, M.A.T.          E-mail: dfrench6@uwyo.edu          Phone: (307) 757-7275
          Dr. Andrea Burrows          E-mail: aburrow1@uwyo.edu          Phone: (307) 766-6735


Office (DF): WH 408 and Phys. Sci. 106          Office Hours: 12:30-23:30 Wednesday in WH 408 or by appointment

Office (AB): McWhinney 314          Office Hours: 9-11a.m. Wednesday in McW 314 or by appointment

Class Meeting Times and Locations: Tuesday & Thursday 9:35-10:50 am, Education Annex 308

Class Website: http://www.aburrows.com/Courses1415/

*Please send all correspondence through emailing both Miss French and Dr. Burrows. Please do not send correspondence through the Wiki.

Prerequisites: Grade of C or better in EDST 3000, 2.75 minimum GPA in major content courses, grade C or better in specific content courses required in the major.

Course Description: EDSE 3275 is the first of a two-course sequence. Science Methods I serve as an introduction to science teaching. Our focus will be to identify attributes of teaching and learning science that are critical to effective instruction. Assignments and activities are intended to have you do things that practicing teachers regularly do. During this course, we will explore science teaching approaches, review national reform documents, and learn about major issues in the field.

LiveText: An active membership to LiveText is a requirement for all Wyoming Teacher Education Program courses. LiveText is a one-time purchase that lasts the duration of your time in the College of Education (up to five years). If you have already purchased a LiveText membership, you do not need to repurchase the software. Teacher education students should purchase the “Field Experience Edition” either at the UW bookstore, or online at livetext.com.

Teacher Education Student’s Role/Expectations: Part of your preparation as a teacher includes following a professional code of behavior and responsibility. Therefore, you are expected to treat all members of the class and your instructor with respect. Plan to attend class, take an active part in discussion or teamwork, and complete all readings and assignments by the deadlines listed in the syllabus. In order to demonstrate your abilities and desire to become a science teacher, you must display the kind of professional behavior and positive attitude you are expected to enact as a teacher graduating from our program.

Professor's Role/Expectations: I will follow a professional code of behavior and responsibility. I will treat all members of the class with respect. I will attend class and take an active part in your learning. I will display the professional behavior and positive attitude that you are expected to enact as a teacher in a classroom. In each
I will ask: 1) What do I want my (future K-12) students to learn, 2) How will they learn it? 3) What do I want them to do with the information? and 4) How will I assess their learning?

I challenge you to ask the same questions in your (future) classroom every day.

Text(s) and Article Readings:

Required Texts:


Articles:


Recommended Supplemental Materials:
American Association for the Advancement of Science, Science for All Americans - Project 2061 ISBN: 0-19-506771-1


Outcomes/Standards: The goals and expectations for the Science Methods I course are based on the College of Education, the Professional Teaching Standards Board (PTSB), and the NSTA Standards for Science Teacher Preparation. You are encouraged to refer to the Teacher Education Handbook. (McWhinnie Hall Education Office, Room 100). It is also expected that by the end of the course, the (future K-12) student will be able to:

1. Demonstrate the implementation of different instructional strategies and teaching materials consistent with the goals of the National Science Education Standards. (Evidence: Article Critique, Demo, Midterm, Microteach, Safety Handbook, Final)

2. Show skills teaching, learning, and assessing in the science classroom. (Evidence: Demo, Midterm, Teaching Philosophy, Microteach, Safety Handbook, Final)

3. Identify and explain a well-thought-out research-based, philosophy of teaching. (Evidence: Midterm, Teaching Philosophy, Safety Handbook, Resources, Reading Summary, Final)

4. Analyze major issues in current science education research. (Evidence: Article Critique, Demo, YouTube Commercial, Reading Summary)
<table>
<thead>
<tr>
<th>CoED STANDARD</th>
<th>PTSB STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. INSTRUCTIONAL STRATEGIES</strong></td>
<td><strong>PTSB I.i: Academic Discipline</strong></td>
</tr>
<tr>
<td>1.1 The pre-service teacher understands, employs, evaluates, and adjusts a</td>
<td>1 The teacher candidate understands the central concepts within the discipline(s) he or she teaches, as stated in the Professional Teaching Standards Board program standards;</td>
</tr>
<tr>
<td>variety of instructional strategies using a wide range of instructional</td>
<td>1.2 is competent in selecting subject matter that addresses the curriculum and standards at the school district, state and national levels;</td>
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<tr>
<td>materials and technology in order to achieve learning goals for all students.</td>
<td>1.3 and believes all students' lives are enhanced through gaining knowledge of the academic discipline.</td>
</tr>
<tr>
<td>1.2 The pre-service teacher understands and applies multiple instructional</td>
<td><strong>PTSB I.ii: Student Learning</strong></td>
</tr>
<tr>
<td>strategies, learning theories, and cognitive processes associated with types</td>
<td>1 The teacher candidate understands all children have similar patterns of learning, and these patterns vary individually within the areas of cognitive, social, emotional and physical development;</td>
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<tr>
<td>of learning.</td>
<td>2 is competent in using developmental theories to provide appropriate learning opportunities to influence all students’ learning;</td>
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<td></td>
<td>3 and is respectful of all students’ diverse developmental levels.</td>
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<tr>
<td><strong>2. DIVERSE LEARNERS/DIFFERENTIATED INSTRUCTION</strong></td>
<td><strong>PTSB I.iii: Students’ Diversity</strong></td>
</tr>
<tr>
<td>2.1 The pre-service teacher understands that schools are comprised of diverse</td>
<td>1 The teacher candidate understands how all students differ in their approaches to learning;</td>
</tr>
<tr>
<td>learners who differ in their approaches to learning</td>
<td>2 is competent in creating instructional opportunities that are adapted to all students' diverse life experiences and developmental levels;</td>
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<tr>
<td>2.2 and that there are multiple theoretical models for understanding and</td>
<td>3 and believes all students benefit from a mutually respectful learning community.</td>
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<tr>
<td>addressing student diversity.</td>
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<td>2.3 He or she plans instruction with the assumptions that all students can</td>
<td><strong>PTSB I.iv: Instruction to Students</strong></td>
</tr>
<tr>
<td>learn and employs instructional methods in ways that connect learning with</td>
<td>1 The teacher candidate is knowledgeable about instructional strategies used to encourage all students' development of critical thinking and problem solving skills and achievement of performance standards;</td>
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<tr>
<td>the students' diverse experiences and needs.</td>
<td>2 is competent in developing students' opportunities to learn.</td>
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<tr>
<td>2.4 The pre-service teacher cultivates a mutually respectful learning</td>
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<td>community that values all students.</td>
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<tr>
<td><strong>3. DEVELOPMENTAL THEORIES</strong></td>
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<tr>
<td>3.1 The pre-service teacher has knowledge of human cognitive, social,</td>
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<td>physical, emotional and moral development, and understands how these factors</td>
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<td>influence learning.</td>
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<td>3.2 The pre-service teacher understands the importance of teacher</td>
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<td>observation of students to gauge developmental abilities;</td>
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<tr>
<td>3.3 Sees development as both a socio-cultural and biological phenomenon;</td>
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<tr>
<td>3.4 Understands the limitations of developmental theories; and</td>
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<tr>
<td>3.5 He or she is capable of forming a responsive pedagogy.</td>
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<tr>
<td><strong>4. DISCIPLINE KNOWLEDGE</strong></td>
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<tr>
<td>The pre-service teacher understands</td>
<td><strong>PTSB I.v: Performance Standards</strong></td>
</tr>
<tr>
<td>4.1 the central concepts of the discipline(s),</td>
<td>1 The teacher candidate is knowledgeable about performance standards;</td>
</tr>
<tr>
<td>4.2 the tools of inquiry used in the discipline(s),</td>
<td>2 is proficient in presenting multiple perspectives, representations, and</td>
</tr>
<tr>
<td>4.3 the structures of the discipline(s),</td>
<td>performance standards within the discipline(s).</td>
</tr>
<tr>
<td>4.4 connections among disciplines,</td>
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<tr>
<td>4.5 and the importance of presenting multiple perspectives and</td>
<td></td>
</tr>
<tr>
<td>representations within the discipline(s).</td>
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</tr>
<tr>
<td>4.6 The pre-service teacher uses these understandings to create</td>
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<td>learning experiences for students that make these aspects of the discipline</td>
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<tr>
<td>(s) meaningful to students.</td>
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<tr>
<td>Source: University of Wyoming, Teacher Education Handbook (p. 40).</td>
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**Standards for Science Teacher Preparation (NSTA, 2011)**
<table>
<thead>
<tr>
<th>NSTA Standard 1: Content Knowledge</th>
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<tbody>
<tr>
<td>Effective teachers of science understand and articulate the knowledge and practices of contemporary science. They interrelate and interpret important concepts, ideas, and applications in their fields of licensure.</td>
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<tr>
<th>NSTA Standard 2: Content Pedagogy</th>
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<tbody>
<tr>
<td>Effective teachers of science understand how students learn and develop scientific knowledge. Pre-service teachers use scientific inquiry to develop this knowledge.</td>
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<tr>
<th>NSTA Standard 3: Learning Environments</th>
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<tr>
<td>Effective teachers of science are able to plan for engaging students in science learning by setting appropriate goals that are consistent with knowledge of how students learn science and are aligned with state and national standards. The plans reflect the nature and social context of science, inquiry, and appropriate safety considerations. Candidates design and select learning activities, instructional settings, and resources—including technology, to achieve those goals; and they plan fair and equitable assessment strategies to evaluate if the learning goals are met.</td>
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<tr>
<th>NSTA Standard 4: Safety</th>
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<tbody>
<tr>
<td>Effective teachers of science can, in a P-12 classroom setting, demonstrate and maintain chemical safety, safety procedures, and the ethical treatment of living organisms needed in the P-12 science classroom appropriate to their area of licensure.</td>
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</table>

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<tr>
<th>NSTA Standard 5: Impact on Student Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective teachers of science provide evidence to show that P-12 students’ understanding of major science concepts, principles, theories, and laws have changed as a result of instruction by the candidate and that student knowledge is at a level of understanding beyond memorization.</td>
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<tr>
<th>Standard 6: Professional Knowledge and Skills</th>
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<tbody>
<tr>
<td>Effective teachers of science strive continuously to improve their knowledge and understanding of the ever changing knowledge base of both content and science pedagogy. They identify with and conduct themselves as part of the science education community.</td>
</tr>
</tbody>
</table>


**Attendance/Participation Policy:** It is expected that you attend class regularly, and your grade will be affected positively if you are present in class. After one absence you will lose points towards your participation grade. Remember the following:

1. University-sponsored absences are cleared through the Office of Student Life
2. Student Health or your private physician may issue a statement giving the dates of student’s confinement whether in the home or hospital due to illness
3. See me immediately about an emergency or religious reason for missing class. (Remember, the dean’s office does not provide authorization for excusing education student absences.)
**Note** - Late work will be accepted up to 24 hours after the assignment due date. The education student will receive a maximum of 75% of the points for late work up to 24 hours after the due date. After 24 hours, zero points will be awarded for the assignment and the assignment will not be graded. Please plan accordingly.

**Note** - Education students who are tardy and/or receive more than one unexcused absence will earn less participation points.

**Use of cellphones and other electronic devices in the classroom:**

Please restrict the use of cellphones and other electronic devices to approved educational use only. Please have all such devices on “silent” mode while in class, unless they are being used for an educational activity. Thank you!

**Dispositions:** The Wyoming Teacher Education Program (WTEP), as a requirement for accreditation, assesses teacher candidates’ “professional behaviors and dispositions.” UW faculty members complete this assessment as well as mentor teachers in specified courses throughout the WTEP and can also be completed at the discretion of any UW instructor. These evaluations will be shared with students/teacher candidates. Any candidate receiving 3 or more ratings of “1” on a professional dispositions assessment, or any teacher candidate receiving 3 or more “1” ratings across multiple professional dispositions assessments, will be required to complete a professional dispositions improvement plan in collaboration with the remediation counselor/Associate Dean. Education students not successfully completing a required improvement plan will not be allowed to continue in the WTEP.

**Academic Honesty:**

The University of Wyoming is built upon a strong foundation of integrity, respect and trust. All members of the university community have a responsibility to be honest and the right to expect honesty from others. Any form of academic dishonesty is unacceptable to our community and will not be tolerated. Teachers and students should report suspected violations of standards of academic honesty to the instructor, department head, or dean.

Academic dishonesty: [http://www.uwyo.edu/as/student-appeals/academic-dishonesty.html](http://www.uwyo.edu/as/student-appeals/academic-dishonesty.html)

**Disability Statement:**
If you have a disability and require accommodations, please let the professor know as soon as possible. (This includes but is not limited to a need for testing accommodations, an interpreter, listening devices, note-taking services, classroom relocation, and/or help during temporary impairments.) You must register with, and provide documentation of your disability to University Disability Support Services (UDSS) in SEO, 109 Knight Hall (Phone: 766-6189).

More information: http://www.uwyo.edu/UDSS/

<table>
<thead>
<tr>
<th>Course Requirements/Assignments for 3275:</th>
<th>Due Date</th>
<th>Points Possible</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Article Critique</td>
<td>9/11</td>
<td>25 pts</td>
<td></td>
</tr>
<tr>
<td>2. Demo Demonstration</td>
<td>9/25</td>
<td>25 pts</td>
<td></td>
</tr>
<tr>
<td>3. Safety Handbook and Free Resources</td>
<td>10/7</td>
<td>55 pts</td>
<td></td>
</tr>
<tr>
<td>4. Teaching Philosophy Summary &amp; Resume</td>
<td>10/14</td>
<td>25 pts</td>
<td></td>
</tr>
<tr>
<td>5. Learning Centers, Subject Integration, &amp; National Standards (10/21)</td>
<td>10/16</td>
<td>75 pts</td>
<td></td>
</tr>
<tr>
<td>6. Misconceptions Microteach (10/23 or 10/28)</td>
<td>10/23 or 10/28</td>
<td>75 pts</td>
<td></td>
</tr>
<tr>
<td>7. Reading Summary Checks (2 @ 10pts each)</td>
<td>11/18</td>
<td>20 pts</td>
<td></td>
</tr>
<tr>
<td>8. Science/Art Integration Project (11/18)</td>
<td>12/4</td>
<td>75 pts</td>
<td></td>
</tr>
<tr>
<td>9. YouTube Commercial (12/4)</td>
<td>12/11 &amp; 12/16</td>
<td>75 pts</td>
<td></td>
</tr>
<tr>
<td>10. Final (Interviews 12/11) (Written 12/16)</td>
<td>Daily</td>
<td>25 pts</td>
<td></td>
</tr>
<tr>
<td>11. Participation (Note: - 5 points for each unexcused absence) (Daily)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>500 pts</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Course Requirements/Assignments for EDCI 5250**

<table>
<thead>
<tr>
<th>All of the above assignments plus the graduate presentation and article summaries</th>
<th>Article Summaries (12 x 12 pts)</th>
<th>144 pts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presentations</td>
<td>36 pts</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>680 pts</strong></td>
</tr>
</tbody>
</table>

**Grading and Point Breakdown:**

The following schedule of percentages will be followed in assigning letter grades:

**Note** - Late work will be accepted up to 24 hours after the assignment due date. The **Education student** will receive a maximum of 75% of the points for late work up to 24 hours after the due date. After 24 hours, zero points will be awarded for the assignment and the assignment will not be graded. Please plan accordingly.
The professor may make changes to the syllabus as the course proceeds. If changes are necessary, these changes will be announced in class and sent by email to the Education students.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Criteria</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Article Critique (25 points)</strong></td>
<td>Assignment Overview: Education students will select a refereed journal article (peer-reviewed) to critique.</td>
<td>9/11/14</td>
</tr>
<tr>
<td></td>
<td>See handout/rubric for more information.</td>
<td></td>
</tr>
<tr>
<td><strong>2. Demo Demonstration (25 points)</strong></td>
<td>Assignment overview: Education students will select a demo to perform in front of classmates.</td>
<td>9/25/14</td>
</tr>
<tr>
<td></td>
<td>See handout/rubric for more information.</td>
<td></td>
</tr>
<tr>
<td>Assignment</td>
<td>Description</td>
<td>Due Date</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>3. Safety</strong></td>
<td><strong>Handbook</strong>&lt;br&gt;<strong>Common Assessment &amp; Free Resources</strong>&lt;br&gt;You will be developing and assembling a science safety handbook for use in your education student teaching placement. This is a common assessment for this course.&lt;br&gt;&lt;br&gt;<strong>Free Resources</strong>&lt;br&gt;You will be gathering free lesson plans, resources, and other useful things you encounter. We will be assembling a class set of these to distribute later.&lt;br&gt;&lt;br&gt;<em>See handout/rubric for more information.</em></td>
<td>10/7/14</td>
</tr>
<tr>
<td><strong>4. Teaching Philosophy &amp; Resume</strong>&lt;br&gt;(25 points)</td>
<td>Assignment overview:&lt;br&gt;You will be writing (or revising a previous) teaching philosophy and resume.&lt;br&gt;&lt;br&gt;<em>See handout/rubric for more information.</em></td>
<td>10/14/14</td>
</tr>
<tr>
<td><strong>5. Learning Centers</strong>&lt;br&gt;(40 points)</td>
<td>Assignment overview:&lt;br&gt;You will be creating two (2) Learning Centers (aka “Activity Centers”) that focus on a misconception in your grade/content area. You will be presenting these learning centers to education students at the Lab School.&lt;br&gt;&lt;br&gt;<em>See handout/rubric for more information.</em></td>
<td>10/16/14</td>
</tr>
<tr>
<td><strong>6. Reading Summary Checks (S1, S2)</strong>&lt;br&gt;20 pts</td>
<td>Description: Education students are required to keep up with readings throughout the semester. There will be two summary checks of reading. Education students may submit the summary in the fashion that will best suit their learning needs including: outline/notes, paragraphs, flow charts, or another instructor approved summary.&lt;br&gt;&lt;br&gt;Task: Education students will turn in a summary of their choice to showcase the reading in the <em>Translating the NGSS</em> by Roger Bybee.</td>
<td>10/2/14 &amp; 10/21/14</td>
</tr>
<tr>
<td>Assignment</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td><strong>7. Misconception Microteach</strong> (50 points)</td>
<td>Assignment overview: Drawing from your experience with the Learning Centers (and from the valuable feedback provided by your classmates and K-12 students at the Lab School), you will be developing a misconception microteach to present in class.</td>
<td>10/23/14 &amp; 10/28/14</td>
</tr>
<tr>
<td><strong>8. Science/Art Integration Project</strong> (30 pts)</td>
<td>Assignment overview: Working with the art education students and Dr. Dambekalns, science education students will plan, create, and present an integrated project with significant science content. <strong>May want to wear old clothing for the two work-days—this could get messy!</strong></td>
<td>11/4/14-11/18/14</td>
</tr>
<tr>
<td><strong>9. YouTube Commercial</strong> (25 points)</td>
<td>Activity Overview: Carl Sagan said we are all made of star-stuff, so this is a chance to highlight your star power! You will focus on one critical issue facing education today. You will describe the issue, discuss its importance, and add suggestions for how to ameliorate the issue. We will be constructively critiquing these videos using YouDemo.info</td>
<td>12/4/14</td>
</tr>
<tr>
<td><strong>10. Final</strong> (75 points)</td>
<td>Assignment overview: Your final will have two parts. The first part is an interview with Miss French and Dr. Burrows. The second part will be an in-class written exam.</td>
<td>12/11/14 &amp; 12/16/14</td>
</tr>
</tbody>
</table>
### Participation (25 pts)

Education students begin with 25 participation points and will lose 5 participation points for any class where the education student is absent (after the first absence) or tardy (3 tardies = 1 absence) or not actively and positively participating and contributing in class activities.

### EDSE 3275 Fall 2014 Course Outline

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Readings</th>
<th>Assignments Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>R 9/4</td>
<td>Introductions &amp; Syllabus</td>
<td>Suggested: Translating the NGSS, Ch. 1</td>
<td></td>
</tr>
<tr>
<td>T 9/9</td>
<td>Becoming a Science Teacher, NGSS, Pt. 1</td>
<td>Suggested: Translating the NGSS, Ch. 2</td>
<td></td>
</tr>
<tr>
<td>R 9/11</td>
<td>5E Learning Cycle Approach &amp; POCARAP, Lesson Plan Template &amp; NGSS, Pt 2</td>
<td>Hart Article: What is the purpose of this experiment?</td>
<td>Article Critique</td>
</tr>
<tr>
<td>T 9/16</td>
<td>Article Discussion &amp; edTPA &amp; NGSS, Pt 3</td>
<td>Suggested: Translating the NGSS Ch. 3</td>
<td>(5250 Article #1)</td>
</tr>
<tr>
<td>R 9/28</td>
<td>Labs/Demos and Nature of Science (NOS) Science Safety</td>
<td>Suggested: Translating the NGSS Ch. 4</td>
<td>NGSS Topic Strand Assessment</td>
</tr>
<tr>
<td>T 9/23</td>
<td>Instructional Theory/History of Science Education Evolution of Standards to NGSS</td>
<td>Suggested: Translating the NGSS, Ch. 5</td>
<td>(5250 Article #2)</td>
</tr>
<tr>
<td>R 9/25</td>
<td>Demo Demonstrations x 4</td>
<td>Suggested: Translating the NGSS, Ch. 6</td>
<td>Demos</td>
</tr>
<tr>
<td>T 9/30</td>
<td>Demo Demonstrations x 4</td>
<td>Suggested: Translating the NGSS, Ch. 7</td>
<td>Demos (5250 Article #3 &amp; 4)</td>
</tr>
<tr>
<td>R 10/2</td>
<td>Misconceptions</td>
<td>Suggested: Translating the NGSS, Ch. 8</td>
<td>Reading Summary Check #1</td>
</tr>
<tr>
<td>10/7</td>
<td>Discrepant Events</td>
<td>Suggested: Translating the NGSS, Ch. 9</td>
<td>Safety Handbook/Free Resources/Lesson Plans</td>
</tr>
<tr>
<td>R 10/9</td>
<td>Activity/Inquiry Options Learning Center Prep</td>
<td>Martin-Hansen article: “Defining Inquiry…”</td>
<td>(5250 Article #5 &amp; 6)</td>
</tr>
<tr>
<td>T 10/14</td>
<td>Assessment Learning Center Prep</td>
<td>Suggested: Translating the NGSS, Ch. 10</td>
<td>Teaching Philosophy &amp; Resume</td>
</tr>
<tr>
<td>R 10/16</td>
<td>Learning Centers (Tentatively scheduled)</td>
<td>Suggested: Translating the NGSS, Ch. 11</td>
<td>Learning Centers (5250 Article #7-8)</td>
</tr>
<tr>
<td>T 10/21</td>
<td>Learning Center Feedback Goals and Objectives</td>
<td>Suggested: Translating the NGSS, Ch. 12</td>
<td>Reading Summary Check #2 (Up to Ch. 12)</td>
</tr>
<tr>
<td>Week</td>
<td>Date</td>
<td>Activity/Task</td>
<td>Notes</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>---------------</td>
<td>-------</td>
</tr>
<tr>
<td>5</td>
<td>10/23</td>
<td>R Misconception Microteach x 4</td>
<td>Translating the NGSS, Appendix A, B, C, OR D (5250 Article #9-10)</td>
</tr>
<tr>
<td>6</td>
<td>10/28</td>
<td>T Misconception Microteach x 4</td>
<td>Microteaches</td>
</tr>
<tr>
<td>7</td>
<td>10/30</td>
<td>R Translating the NGSS &amp; Microteach wrap-up</td>
<td>Science &amp; Art Integration Project, Part 1 (5250 Article #11 &amp; 12)</td>
</tr>
<tr>
<td></td>
<td>11/4</td>
<td>T Science &amp; Art Integration Project, Part 1</td>
<td>Article 1</td>
</tr>
<tr>
<td>8</td>
<td>11/6</td>
<td>R Science &amp; Art Integration Project Work Day</td>
<td>Article 2</td>
</tr>
<tr>
<td>9</td>
<td>11/11</td>
<td>T Science &amp; Art Integration Project Work Day</td>
<td>Article 3</td>
</tr>
<tr>
<td>1</td>
<td>11/13</td>
<td>R Science &amp; Art Integration Project, Part 2</td>
<td>Article 4</td>
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<tr>
<td>2</td>
<td>11/18</td>
<td>T Science &amp; Art Integration Project Presentations</td>
<td>Art &amp; Science Presentation (5250 Presentations)</td>
</tr>
<tr>
<td>3</td>
<td>11/20</td>
<td>R 5250 Presentations</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>11/25</td>
<td>Science Safety Seminars</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11/27</td>
<td>R Thanksgiving</td>
<td>No Class!</td>
</tr>
<tr>
<td>6</td>
<td>12/2</td>
<td>T Instructional Technology</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12/4</td>
<td>R Education Student Teaching Preparation Guest Speaker &amp; Preparing for Job Search in Education YouDemo Critique</td>
<td>YouTube Commercial Due</td>
</tr>
<tr>
<td>8</td>
<td>12/9</td>
<td>T Engineering Careers, Integrating Engineering in the Science and Math Classroom</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>12/11</td>
<td>R Review &amp; Final Interviews</td>
<td>Bring review questions Interviews</td>
</tr>
<tr>
<td>10</td>
<td>12/16</td>
<td>Final Exam</td>
<td>(Dec. 16 @ 10:15-12:15 pm) Final</td>
</tr>
</tbody>
</table>

**Important note:** If you are in EDCI 5250 - Advanced Topics in Pedagogy

The general information in the syllabus for EDSE 3275 stands for this class as well.

Coursework for this class:

You will need to read twelve (12) articles, individually summarize them, and prepare a group presentation for the class. It is up to you to pace yourself in this graduate class. There will be minimal checks on your progress before the presentation and summaries are due.

- The group presentation will be on Nov. 20 at the beginning of EDSE 3275 class.

Each summary should be between 250 and 350 words and describe the following:

1. What is the main point of the article?
2. Who would be interested in this article and why?
3. How could this article influence your teaching of science and why?
4. Do you agree or disagree with any parts of the article and why?
5. What could you do in your class to test any of your ideas generated by this article?
6. How does this article relate to what you’ve read and heard?

Articles:
11. Refereed [research] journal article highlighting an aspect of STEM of your choice.
12. Refereed [research] journal article highlighting an aspect of STEM of your choice.

Grade:
Your grade in this class will be dependent on your part of the group presentation and each of your six summaries.

Out of 180 points:
Presentation 36 pts—1 slide/article. Include the main points as well as how you can use the information in the article in your classroom.
12 Articles 144 pts (12 pts each - 2 pts per question listed above)

Appendix B. EDCI5250 Course Syllabus: the course incorporates five-sessions of a science and art-integration unit within the 16-week course.
Appendix C

Science & Art Education Integration Project Syllabus

Dr. Dambekalns, Dr. Burrows, and Miss French

Methods I

Fall 2014

Both artists and scientists possess abilities that distinguish them from other professions. They observe and notice small details, explore ways to approach their projects, solve problems, make their creations available for public scrutiny, and communicate their final products. The interaction of art and science can be found when students explore changes in nature, record and organize data, and report findings. In school, art and science teachers can work together instructing students on methods and media, especially on techniques that lend themselves to gathering information quickly.

Below is a tentative schedule for this collaborative project. As you know, art and science are both iterative, messy process and we appreciate your patience and flexibility! Thank you!

Day 1: Tuesday, November 4 – EA 308

- Meet Art Ed Methods Students
- Fun with Forms
- Pre-survey
- Microteach from Art & Science Students

Task: Due Today!

- Develop a microteach on the following topics:
  - Surface Tension, Surfactants, Adhesion, Cohesion
  - Primary Colors of Light & Color Addition of Light
  - History/Chemistry of Paints

Day 2: Thursday, November 6 – ED 30 – Exploring Connections: The Sampler

- Resist Lines Drawn – Dr. Dambekalns will explain the use of resist
- Sampler Stages Will Be On Display
- A Batik Sampler Will Be Made

Task:

- Look for 4-5 Full-Color Micro Images
- Begin Reading STEAM Articles
### Day 3: Tuesday, November 11 – ED 30

- Work With Team to Finalize a Suitable Image for the Larger Batik Work
- Must be a *micro image*.
- Sketch Out Lines with Charcoal and Add Resist on the Larger Sampler

**Task:**
- Bring 4-5 Full-Color Micro Images (can be biology-related or particle physics)
- Continue reading STEAM Articles
- Collaborate For Presentation

### Day 4: Thursday, November 13 – ED 30

**The Goals For Today’s Meeting Are to:**
- Work With Your Teammates in Creating a Work That Portrays Science Content
- Remember to Use Color Mixtures and Textural Techniques in Your Batik Work
- Finish You Large Batik Work
- Finish Your Discussion Worksheet While the Group Creates and Finishes the Work

**Task:**
- Continue Reading STEAM Articles
- Collaborate For Presentation

**Bring (if able):**
- Hair Dryer
- Iron

### Day 5: Tuesday, November 18 – EA 308

**The Goals For Today’s Meeting Are to:**
- Video Record and Present Your Batik Work (You are responsible for the recording).
- Explain the art content (use at least 5 explicit vocabulary terms)
- Explain the science content (use at least 5 explicit vocabulary terms)
- Explain how an integrated project like this would be useful in your classroom
- Post-survey

**Note —** We will be documenting (by video and photo) the activities of this integration. You will not be filmed or photographed if you have expressed this to Dr. Dambekalns and/or Dr. Burrows.
Appendix C. An organized schedule of activities and objectives set for the Science and Art-integration unit for the science and art education methods courses. This was given at the beginning of the unit to present the idea, objectives, and layout of the unit to pre-service teachers.
Appendix D
Science & Art-Integration Unit Grading Rubric

This is a wonderful chance to work with other colleagues in education.

You have ideas to give them and they have ideas to give you. Collaboration is wonderful!

You are in a mixed group. For Science Methods, the project is worth a maximum of 75 Points

Here is the breakdown of how you can earn points:

Project Portfolio of this joint experience includes the following:

1) 10 points ______ Discussion worksheet filled out thoroughly and completely by group.
2) 15 points ______ Batik small sampler using geometric patterning with required varied color mixtures and textural techniques
3) 25 points ______ Participation in microteach, painting group piece, and presentation (5 points per day). Final large piece worked on jointly in a group.
4) *15 points ______ Assessment of learning (uploaded pictures and link to video in LiveText) You will need to upload into LiveText:
   a. Digital photo of the micro-model picture that you used (2 points)
   b. Digital photo of the painting your group created (2 points)
   c. YouTube link to the group video presentation (2 points)
   d. 1-2 page content statement explaining:
      i. Discipline CONCEPTS (Art and Science) - ...highlight the 5 vocabulary terms from each discipline (5 points) and explain applicable crosscutting concepts and NGSS (3 points)
      ii. How YOU specifically contributed to the project (1 point)
5) 10 points ______ Presentation (with participation) on Tuesday, November 18
   a. You must have a specific part to talk about and/or show (3 points)
   b. Remember to highlight the 5 vocabulary terms from each discipline (3 points)
   c. Remember to focus on your article and how it relates to your project (3 points)
   d. Each group must record the presentation (and then upload the video link) (1 point)

*Part 4 from above (Assessment of learning) should all be uploaded into LiveText.
Note – This is a collaborative experience – a partnership that we hope you continue – and a project that you should keep as documentation on your ability to plan interdisciplinary units. You might want to highlight this experience during your teaching interviews as well!

Appendix D. A rubric was presented to each pre-service teacher to show the breakdown of what was expected to be turned in for assessment. Pre-service teachers were able to work collaboratively on majority of the unit assessments, alongside providing individual reflection and insight through a sampler batik and Assessment of Learning paper.
# Appendix E

## Silk Batik Instructions Sheet

**Materials:** (Note: we ordered from Dharma Trading company which carries both the silk and all sorts of fabric paints/dyes. Their Website is [www.dharmatrading.com](http://www.dharmatrading.com))

<table>
<thead>
<tr>
<th>Materials</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vine Charcoal</td>
<td>Ice Cube Trays to Use as Palettes</td>
</tr>
<tr>
<td>Resist – washable (you can use Jacquard brand or silk paint brand)</td>
<td>Eyedroppers and/or Syringes For Moving Colors Out of Containers</td>
</tr>
<tr>
<td>Dyes or Flow able Paints</td>
<td>Scrap White Paper to Drawn on and to Practice Mixing Colors on</td>
</tr>
<tr>
<td>Salts (table and rock)</td>
<td>Paper Towels for Clean Up</td>
</tr>
<tr>
<td>Ammonia, Vinegar, Alcohol, etc.</td>
<td>Water &amp; Containers</td>
</tr>
<tr>
<td>Frames to Stretch Silk On</td>
<td>Silk</td>
</tr>
<tr>
<td>Pins, Rubber bands, or Pantyhose</td>
<td>Hair Dryer</td>
</tr>
<tr>
<td>Brushes (soft watercolor are best) and Q-Tips</td>
<td>Hot Iron</td>
</tr>
</tbody>
</table>

**Sampler Steps:**

1. Use charcoal to lightly trace design onto the silk
2. Resist the lines using thin even lines going out to the edge of material
3. Dry resist lines either naturally or with blow dryer
4. Fix your palettes with basic colors using eyedroppers
5. Gather the following:
   a. Soft brushes and Q-tips
   b. Paper Towels
c. 2 Containers for Water (1 for cleaning and 1 for diluting)
d. Salt and other reactants (i.e. ammonia, alcohol,) for special effects
e. Hair Dryer

6) Apply dyes according to your ideas
7) Allow dyes to dry
8) SET the color using a hot iron, making sure the whole pieces feels hot to the touch for about 2 or 3 minutes. Letting it sit overnight helps insure color retention.
9) Gently wash out the resist lines in room temp water. Hang or flap to dry.
10) Iron lightly with cool iron (low setting) if you want to make it glisten even more.

Final Piece: Repeat sampler steps; just do them on a large scale if you want to create a group banner.

Important Tips:

- Suspend silk when resisting and when painting! If not, your colors will mix and get muddy
- Watch out to completely close all resist lines or you’ll get leakage
- Set colors with hot iron before you wash out resist lines. Let it stay hot for a bit, maybe counting to 8 seconds. Each second before moving on (but do not leave iron on silk or it will burn it).
- Wash out resist lines with lukewarm water by hand.

Appendix E. A silk batik process instruction sheet was distributed to refer back to when constructing individual and group piece.
Appendix F

Individual Image Sampler Example

Figure 16. Individual Silk Batik Sampler
Appendix G

Whole Class Individual Samplers

Figure 17. Examples of Cohort 3’s Individual Silk Batik Samplers

Note: Both the science and art pre-service teachers created all displayed individual samplers. The individual samplers were not organized by discipline or ability, and could not be identified to a specific art or science pre-service teacher.
Appendix H

Small Group Silk Batik Example
Figure 18 Examples of Group’s Large Silk Batik

Note: The top image in the entire interpretation of a microscopic snowflake image. The bottom left image is the original image retrieved from (https://www.flickr.com/photos/chaoticmind75/6922463361) and the bottom right image is a close up of the silk batik.
Appendix I

Science & Art-Integration Unit Pre-Service Teacher Survey

Please, identify your survey with 3 or 4 letter code (or nickname) of your choice so that your pre and post survey forms can be matched. __________________________.

Date: __________________________

Please circle your area of study:
A. Art Education
B. Science Education (Area of Specialization: ____________________________)

Instructions:
Please indicate your knowledge of each item using the scale below:

1 = least to 10 = most

1. Ways to engage learners with interdisciplinary connections.

2. The usefulness of satellite imaging as a context for classroom learning.

3. Ways to develop an interdisciplinary unit

4. The use of visual literacy made by both artists and scientists

5. Implementation of instructional activities for visual learners in your discipline

6. The physical principles of mediums

7. Using scientific images as an aesthetic tool

8. Ways to integrate art and science
Overall, what is the: 
1 = least to 10 = most

9. Level of artistic skills that you bring to this project

10. Level of scientific skills that you bring to this project

11. Level of previous experience with artistic mediums

12. Level of previous experience with scientific mediums

13. Level of previous experience with collaborative work with pre-service teachers from ANY other disciplines

14. What benefits do you see in this art/science -integrated unit?

15. What challenges do you see in this art/science-integrated unit?

16. How do artists and scientists practice similar skills?

17. What is a partnership?

18. Why would you use (or not use) partnerships as you teach?

19. Is a partnership different from collaboration? If yes – how? If no – why not?

Appendix I. The same survey was distributed to each pre-service teacher at the beginning and completion of the Science and Art-integration unit. The survey had a variety of quantitative questions relating to self-rating and confidence, skills and experiences, and qualitative questions for open-ended responses.
Appendix J

Science & Art-Integration Unit Small Group Discussion Sheet

1. What positive skills and/or attitudes do each of you bring to the group?

<table>
<thead>
<tr>
<th>Name – Group Member</th>
<th>Skill/Attitude 1</th>
<th>Skill/Attitude 2</th>
<th>Skill/Attitude 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

2. What phase(s) of an inquiry project will be enhanced from collaborative art and science work? How?

<table>
<thead>
<tr>
<th>Inquiry Project Parts</th>
<th>Project Enhanced?</th>
<th>Yes? Answer “how”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posing a Question</td>
<td>Yes or No</td>
<td>No? Answer “why not”</td>
</tr>
<tr>
<td>Finding Resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collecting Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyzing Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing Iterations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporting Findings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. What are some specific topics that could be covered through this integrated activity?

<table>
<thead>
<tr>
<th>Specific Topics</th>
<th>Content Knowledge</th>
<th>Art =</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Science =</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Affect/Attitudes</th>
<th>Art =</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Science =</td>
</tr>
</tbody>
</table>
4. Make a list of potential cross-curricular connections from an integrated art/science unit:

<table>
<thead>
<tr>
<th>Science &amp; Art Cross-Curricular Concepts*</th>
<th>How science is related to...</th>
<th>How art is related to...</th>
<th>What other discipline is related?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause &amp; Effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Models</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diversity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principles of Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critiquing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*See how the Science and Art concepts are grouped below:

- Consider the 9 crosscutting concepts: organization, cause and effect, systems, scales, models, change, structure and function, variations, and diversity. Consider how these concepts shape the knowledge and experiences in Arts and Sciences.
- Consider the 4 basic artistic concepts: planning, element/principles of design, investigation, critiquing. Consider how these concepts shape the knowledge and experiences in Arts and Sciences.
5. There are strengths and challenges in this integrated activity for both artists and scientists as they conduct their creations and investigations. Name some challenges for each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Strengths</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artists</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. What thoughts or comments does your group have about this integrated Science and Art project?

Appendix G. A science and art discussion worksheet was given to each group. Each group was to provide a filled-in worksheet that documented group thoughts, perspectives, ideas, and opinions regarding the unit. This worksheet was to be filled in during the unit as a graphic organizer of thoughts.
Appendix K

Researcher's Small Group Interview Questionnaire

Name: ________________________________
Art or Science: __________________________
Concentration: __________________________

Before Unit:
• Did you know you would be working in a science and art integration unit at the beginning of course?
• How did you feel when you found out you were going to work with science methods pre-service teachers/individuals?
• What were you worried about going into the project?

During the Unit:
• How did you feel after the first day of the Art and Science integration?
• What did you think of the main objectives/processes of the Art and Science integration?
• What did you think of your group? Strengths? Weaknesses?

After the Unit:
• What was your attitude towards this unit? Afterwards.
• How did you feel about the collaboration between the art and science disciplines working together?
• What was your overall impression of the art and science integration after you completed the unit? What was your attitude after this unit?
• Would you ever consider incorporating the opposite discipline (art) in your classroom? And How? Art teacher help?
• Other Overall Comments?

Appendix K. List of questions researcher asked to her peers in her small group
### Appendix L

**Pre- & Post- Survey Statistics Table**

Table 5 Full Statistical Summary of Confidence in Knowledge and Skill Levels

<table>
<thead>
<tr>
<th>Question</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Survey Mean (SD)</td>
<td>Pre-Survey Variance</td>
<td>Post-Survey Mean (SD)</td>
</tr>
<tr>
<td>1</td>
<td>6.63 (1.81)</td>
<td>3.47 (0.87)</td>
<td>0.80</td>
</tr>
<tr>
<td>2</td>
<td>4.79 (2.35)</td>
<td>5.84 (1.09)</td>
<td>1.25</td>
</tr>
<tr>
<td>3</td>
<td>6.05 (1.88)</td>
<td>3.71 (0.99)</td>
<td>1.04</td>
</tr>
<tr>
<td>4</td>
<td>6.42 (2.32)</td>
<td>5.7 (0.76)</td>
<td>0.61</td>
</tr>
<tr>
<td>5</td>
<td>7.26 (1.58)</td>
<td>2.65 (0.79)</td>
<td>0.65</td>
</tr>
<tr>
<td>6</td>
<td>6.16 (2.32)</td>
<td>5.7 (1.13)</td>
<td>1.36</td>
</tr>
<tr>
<td>7</td>
<td>5.42 (2.52)</td>
<td>6.7 (0.86)</td>
<td>0.78</td>
</tr>
<tr>
<td>8</td>
<td>5.53 (1.96)</td>
<td>4.04 (0.94)</td>
<td>0.94</td>
</tr>
<tr>
<td>9</td>
<td>6.63 (2.74)</td>
<td>7.91 (2.36)</td>
<td>5.88</td>
</tr>
</tbody>
</table>
## Appendix M

### Skills Acquired from Science & Art-Integration Unit & Alignment with Standards

<table>
<thead>
<tr>
<th>Bloom’s Taxonomy</th>
<th>Pre-Service Teachers Skills Acquired</th>
<th>K-12 Students Skills Acquired</th>
<th>Alignment of Next Generation Science Standards</th>
<th>Alignment of WY Fine &amp; Performing Art Standards</th>
<th>Alignment of WY Science Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge:</strong></td>
<td>Student recalls or recognizes information</td>
<td>-Recalls NGSS, WY State Science or Fine &amp; Performing Arts from methods courses</td>
<td>-Recalls previous art and science knowledge and experiences</td>
<td>-Starting with any Disciplinary core idea (K-12 Curriculum)</td>
<td>Depends on the image used. However, many of the SC 11.1 Concepts and Processes Content Standards can be addressed by using a variety of images from all realms of science.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Relates own discipline into Science &amp; Art-integration unit</td>
<td>-Records silk batik instructions</td>
<td>-Asking Questions and defining problems in 9-12 builds upon K-8 experiences and progresses</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Repeats silk batik activity through sampler and larger group silk batik</td>
<td>-Recalls previous art and science knowledge and experiences</td>
<td>-Recalls previous art and science knowledge and experiences</td>
<td></td>
</tr>
<tr>
<td><strong>Comprehension:</strong></td>
<td>Student changes information into a different symbolic form/language</td>
<td>-Explains his or her own discipline to others through microteaches</td>
<td>-Interprets and explains a scientific image through a silk batik art project</td>
<td>-Scale, Proportion, &amp; Quantity: some systems can be only studied indirectly as they are too small, too large, too fast, or too slow to observe directly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Reviews scientific or artistic topics with peers through demonstrations or hands-on activities</td>
<td>-Interprets and explains a scientific image through a silk batik art project</td>
<td>-Interprets and explains a scientific image through a silk batik art project</td>
<td></td>
</tr>
<tr>
<td><strong>Application:</strong></td>
<td>Student solves a problem by using the knowledge and appropriate generalizations</td>
<td>-Demonstrates a scientific concept or process through an artistic concept or process</td>
<td>-Demonstrates silk batik process by illustrating macroscopic and microscopic images onto silk</td>
<td>-Developing and Using Models: design a test of a model to ascertain its reliability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Relates how this integration unit can be incorporated into their future classroom</td>
<td>-Applies knowledge on color mixing, dye application, and artistic terminology in silk batik</td>
<td>-Planning and Carrying Out Investigations: selecting appropriate tools to collect, record, analyze, and evaluate data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Practices an activity that can be transferred into future classroom</td>
<td>-Recalls scientific processes of microscopic or macroscopic image being represented in silk</td>
<td>-Recalls scientific processes of microscopic or macroscopic image being represented in silk</td>
<td></td>
</tr>
<tr>
<td><strong>Analysis:</strong></td>
<td>Student separates information into component parts</td>
<td>-Compares and contrasts similarities between science and art disciplines</td>
<td>-Compares artistic representation with actual image for likeness</td>
<td>-Systems &amp; System Models: models can be used to simulate systems and interactions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Criticizes benefits and challenges of a science and art-integration unit</td>
<td>-Experiments and tests with dyes, salts, and application techniques</td>
<td>-Analyzing and Interpreting Data: building on K-8 experiences, comparison of data sets for consistency and use of models to generate and analyze data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Differentiates artists and scientific concepts explored within the silk batik activity</td>
<td>-Questions composition in image representation</td>
<td>-Questions composition in image representation</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FPA 11.1.A.3: Students plan and create artistic works based on use of design elements and principles.

FPA 11.1.A.2: Students envision, create, communicate experiences and ideas, and work toward artistic goals through the use of media, techniques, technologies, and processes.

FPA 11.1.A.4: Students collaborate with others in creative artistic processes.

FPA 11.2.A.1: Students observe and describe in detail the physical properties of works of art.

FPA 11.2.A.4: Students form and defend their preferences for artists, specific works and styles.

FPA 11.3.A.3: Students analyze relationships of works of art to one another in terms of history, aesthetics, environment, and
culture and place their work within the continuum of the visual arts.

### Synthesis:
- Proposes ways that art and science can be taught in the same classroom
- Collects experiences of science and art-integration unit
- Prepares a presentation of experiences and perceptions had during unit
- Creates representation and model of scientific images onto a different medium
- Designs a plan (with others) on how to approach silk batik problem/project
- Engaging in Argument from Evidence: making and defending claims based on evidence
- Obtaining, Evaluating, and Communicating Information: reading scientific literature to determine central ideas or conclusions to summarize evidence and information
- FPA 11.4.A.1: Students synthesize the creative and analytical process and techniques of the visual arts and other disciplines.
- SC 11.3.1: Students examine the nature and history of science
  - As scientific knowledge evolves, it impacts personal, social, economic, and political decisions.

### Evaluation:
- Evaluates the integration unit as something a pre-service teacher would incorporate into their future classroom
- Selects and chooses what was successful and challenging of unit
- Rates their experience and perceptions through pre- and post-surveys
- Evaluates presentation and explanation of scientific concept or process through the art product
- Selects and chooses what was successful and challenging of project
- Constructing Explanations and Designing Solutions: making quantitative and qualitative claims regarding relationship between dependent and independent variables.
- FPA 11.4.A.2: Students identify artistic skills and determine how they apply a variety of careers and recreational opportunities
- SC 11.3.2: Students examine how scientific information is used to make decisions.
  - Interdisciplinary connections of the sciences and connections to other subject areas and career opportunities

Table 6 Bloom’s Taxonomy & Standards Connection to the Science & Art-Integration Unit