CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

INTEGRATING ARTS INTO STEM CURRICULUM DESIGN TO REDUCE TEACHER ANXIETY

A graduate project submitted in partial fulfillment of the requirements

for the Degree of Master of Arts in Education,

Elementary Education

by

Donna Louise Blankenship

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Due to the ever changing global economy and the increasing need to address issues such as climate change, pollution, and natural resources it is imperative that our students today become well versed in science, technology, engineering, and, mathematics (STEM). Research shows that American students fall far behind their counterparts in other developed nations and students interested in STEM careers falls short of the growing need. Unfortunately, many elementary teachers feel anxious or unprepared to teach STEM curriculum. This graduate project looks at some of the concerns, such as math and science anxiety, that teachers at one school may experience. The project suggests that arts integration, turning STEM into STEAM, may be one method that teachers find engaging. The project details the development of a five week arts integrated STEM unit of instruction developed around the theme of sea turtles and the ocean. The unit integrates standards from Common Core ELA and math, Next Generation Science Standards (NGSS), and Visual and Performing Arts (VAPA). The project also addresses concerns teachers have expressed regarding the lack of engaging and meaningful professional development received through the district. The project details a two hour professional development (P.D.) that informs teachers about STEM and demonstrates best practices and pedagogy. In an attempt to promote continued growth the project finally suggests creating a professional learning community (PLC).

CHAPTER ONE

Introduction

Purpose

The purpose of this project was to develop and implement an integrated arts and STEM professional development program and curriculum designed to reduce math and science anxiety experienced by K-5 teachers at Castlebay Lane Charter Elementary School. The goal of the program was to improve teacher engagement levels and subsequently increase time on task for lesson development and implementation.

Background Information

As we enter into the twenty-first century, our American education system must develop students prepared to fill the ever increasing number of STEM (science, technology, engineering, and math) careers. Many U.S. businesses are expressing concern over the lack of qualified applicants in this country (Langdon, McKittrick, Beede, Beethika, & Doms, 2011). Careers in the STEM fields are projected to grow at a staggering 17% between 2008 and 2018 (Langdon et al., 2011). This concern has not gone unnoticed by the Obama Administration which has created a committee on STEM education and is looking at current policies and programs (Committee on STEM Education National Science and Technology Council, 2011).

Of particular concern is the efficacy of mathematical instruction in this country (Geimer, 2014). Research has shown that student performance on problem solving tests is only slightly above average compared with the results of other industrialized nations (PISA, 2012). There are myriad reasons why math instruction is ineffective including, but not limited to, math anxiety experienced by teachers and lack of engaging math instruction (Geimer, 2014; Jackson & Leffingwell, 1999; Meece, Wigfield, & Eccles, 1990).

If we are to prepare today's youth for tomorrow's STEM careers it is incumbent upon the education system to investigate the sources and treatment of math anxiety, as well as, the instructional models adopted by educators. Research indicates that many pre-service teachers who experience anxiety over teaching curriculum in the STEM fields have low levels of self-efficacy, but can improve their attitudes after receiving training and education in content and pedagogy (Velthuis, Fisser, & Pieters, 2013). Additionally, a more engaging format for the delivery of STEM instruction may be the integration of arts. Research indicates that arts integration improves problem solving strategies, allows for greater student engagement, provides multiple entry points to instruction, and improves communication (Barrett, Everett & Smigiel, (2012); Gullatt, 2008; Sloan, 2009).

Statement of the Problem

Teachers are required to implement mathematics instruction that reflects the Common Core State Standards (CCSS) adopted in 2010. On the horizon is the full implementation of the NGSS (Next Generation Science Standards) adopted in 2012. When teachers experience anxiety related to the pedagogical content knowledge (PCK) of a subject, such as science, they tend to either avoid teaching the subject or look towards specific activities that work (Appleton, 2003).

Brief Review of Methodology

For the purpose of this project, I developed and implemented an arts integrated STEM curriculum designed to reduce math anxiety levels of teachers at Castlebay Lane Charter Elementary School. The project consisted of three phases. First, I administered pre- and post- questionnaires in order to determine levels of STEM anxiety and self-efficacy. These questionnaires were used soley to determine teacher needs and inform the design of the professional development sessions. Second, all teachers participated in a total of two hours of professional development (P.D.) designed to guide teachers in developing arts and STEM integrated lessons. During the professional development I presented background information on the critical importance of STEM curriculum, and had teachers participate in an arts integrated STEM lesson. In addition teachers received information on professional learning communities (PLCs) and I determined staff interest in creating a PLC at Castlebay for the purpose of developing arts integrated STEM lessons and curriculum. Moreover, following the presentation teachers were asked to develop on integrated lesson appropriate to their grade level. Lastly, I developed a fourth grade, five week unit that includes multiple lessons that integrate arts into STEM.

CHAPTER TWO

Literature Review

Extensive research has examined STEM anxiety and its link to teacher beliefs about self-efficacy (Nadelson, Callahan, Pyke, Dance & Pfiester, 2013; Pop, Dixon, & Grove, 2010). While many teachers may experience math anxiety, which has been linked to science anxiety (Bursal & Pasnokas, 2006), the arts have been universally appealing to children and represent the interests of many teachers (Gullatt, 2008). In addition, the integration of arts into the curriculum has been shown to improve problem solving skills and creative thought so critical to the development of the future STEM generation (Bresler, 1995; Gullatt, 2008). Nonetheless, many teachers still experience anxiety as related to math instruction. The next section explores these issues in further depth.

Math Anxiety

The idea that teachers experience math anxiety has been widely studied and documented (Beilock, Gunderson, Ramirez, & Levine, 2010; Jackson & Leffingwell, 1999; Newton, 2009). This is concerning as it affects students in a variety of ways. In a two year longitudinal study research indicated that students, especially female students, were less likely to choose higher level, college preparation math classes if they had not learned to value math (Meece, Wigfield, & Eccles, 1990). Students preparing for teaching credential certification participated in a qualitative study looking at prior math experiences. It was found that only seven percent reported only positive experiences in their own math instruction (Jackson & Leffingwell, 1999). These negative experiences regarding math were often attributed to the teaching style of the instructor as many students internalize the enthusiasm and interest in math that is expressed by their teacher (Jackson & Leffingwell, 1999).

Looking back at the earlier experiences of students the math anxiety of a teacher in lower elementary grades can have a significant effect. Researchers looked at the effect of female teachers' math anxiety on students and found a particularly disturbing gender trend (Beilock et al., 2010). First and second grade students were tested at the beginning of the year and then again at the end of the year to establish levels of achievement. They were also asked at the beginning of the year to answer questions regarding their beliefs in certain gender based stereotypes. The study concluded that by the end of the year girls who adhered to a gender based stereotype were more likely to have lower math achievement scores when they had female teachers who exhibited math anxiety (Beilock et al., 2010). In addition, anxiety related to spatial reasoning has also been shown to negatively impact student outcomes in first and second graders (Gunderson, Ramirez, Beilock, & Levine, 2013). The study concluded that this may be due to the fact that teachers who do not feel comfortable with spatial reasoning themselves tend not to integrate it into the curriculum as it is not a specific math standard (Gunderson et al., 2013).

Experiencing math anxiety can have far reaching effects on other areas of STEM. In a quantitative study, pre-service teachers were asked to respond to the R-MANX (Revised Math Anxiety Survey), the MTEBI (Math Teaching Efficacy Belief Instrument), and the STEBI (Science Teaching Efficacy Belief Instrument). The results indicated that pre-service teachers who scored highly on the R-MANX performed poorly on the MTEBI, and they also scored low on the STEBI indicating a connection between math and science self-efficacy (Bursal & Pasnokas, 2006). Given the effect that teachers' low self-efficacy in math and science can have upon their students when it comes to achievement the need to look at the professional development of teachers in the area of STEM has to be addressed.

Professional Development

The level of math, and consequently science, anxiety experienced by pre-service and practicing teachers is of particular concern as educators move towards implementing the CCSS and the NGSS. During the last round of standards adoptions (CA math in 1997 and CA science in 1998), a variety of professional development (P.D.) models, aimed at improving teacher content knowledge and pedagogy, were studied (Gabriele & Joram, 2007; Shriner, Schlee, Hamil & Libler, 2009; Pop, Dixon, & Grove, 2010). Several general themes emerge from this research: the structure of the P.D., the level of experience of the teachers involved, teachers' self-expressed needs, and their pre-existing belief systems.

The design of a P.D. needs to address math or science content and pedagogy regardless of its duration. In a longitudinal study of teachers in the western United States, researchers found that, while anxiety levels were high among many elementary teachers when it came to teaching STEM subjects, participation in a three-day summer institute reduced anxiety and increased levels of self-efficacy (Nadelson et al., 2013). At the end of the P.D., teachers expressed the greatest concern over STEM integration with other curriculum (Nadelson et al., 2013). The preoccupation with integration into classroom routines is echoed by teachers in a study conducted in Australia; teachers need to feel involved in the content and see its relevance to the day-to-day operations of the classroom (Comber, Kamler, Hood, Moreau, & Painter, 2004). One approach to utilizing teachers as the experts in their own classrooms is to structure the P.D. as a research project (Pop et. al., 2010). In a Research Experiences for Teachers (RET) program, teachers worked alongside scientists during a summer institute to work through the steps of scientific exploration. At the end of the experience, elementary teachers reported having a better understanding of science pedagogy and how their students would approach scientific thinking (Pop et al., 2010). Providing opportunities for teachers to reflect and explore their own metacognition was the focus of a quantitative study by Gomez-Zweip and Benkin (2012). Teachers attended one week summer workshops with follow-up sessions for collaboration during the school year. Elementary teachers' perceptions of what math and science were changed from subjects that have many facts and information to be memorized to subjects that have thinking processes (Gomez-Zweip & Benkin, 2012). In another study teachers participated in a two week summer workshop in which they participated in the scientific inquiry method and experienced problem-based learning (PBL). The PBL approach helped teachers to connect the subject matter to the needs of their rural students. When given the opportunity to reflect upon the process and their own learning they had increased self-efficacy (Ertmer, Schlosser, Clase, & Adedokun, 2014).

While the structure and content of the P.D. can affect a teacher's perception of the subject, the P.D. must also meet the needs of the beginning teacher, one in mid-career, and the well-seasoned veteran. A quantitative study undertaken in the Netherlands used a version of the SoCQ (stages of concern questionnaire) to identify the concerns of teachers as they implemented a new math curriculum over a rolling period of several years

(Christou, Eliophotou-Menon, & Philippou, 2004). The findings indicated that inexperienced teachers were more concerned with the execution and management of the task than experienced teachers, who considered the success of their students, regardless of whether they had one, two, or three years of exposure to the program (Christou et al., 2004). The idea that teachers will go through stages of development in their own professional learning is also supported by a qualitative study undertaken by Gabriele and Joram (2007). Despite the fact that all ten teachers participating in the study had over ten years of teaching experience, those that were new to the mathematics teaching practices program indicated concerns over daily implementation and meeting the goals of the program over student outcomes, which became the concern of teachers who had participated in the program for a longer period of time (Gabriele & Joram, 2007).

The structure and content of the P.D., teachers' years of experience, and their exposure to the new material all contribute to the success of professional learning, but teachers must perceive a value and have their needs met by the professional learning experience (Gabriele & Joram, 2007; Shriner et. al., 2009). A study undertaken in Tasmania investigated the needs of teachers as they incorporated new mathematical standards (Beswick, 2014). The researchers found that teachers have three distinct categories of need: specific content or resource needs teachers are willing to share due to the fact that those needs are outside-of-self issues; needs teachers are not willing to voice due to the fact that they might seem incompetent; and needs of which they are not presently aware (Beswick, 2014). If one expects teachers to explore these needs there must be a perceived value to the P.D. This value is realized through successful experiences in the classroom (Gabriele & Joram, 2007; Shriner et al., 2009). Without these successful experiences and given a life-time of preconceived ideas about education and its implementation, professional development opportunities will be undervalued and rejected if the creators of the P.D. are not sensitive to the needs and experiences of the teachers involved (Ebert & Crippen, 2010).

Professional Learning Communities (PLCs)

Unfortunately, while research exists to support the length and structure of professional developments that can have long lasting effects, the current educational environment has both time and budget restrictions that impede this type of training. An alternative to P.D.s is the professional learning community (PLC). In their review of PLCs in 2012, Riveros, Newton, and Burgess note that some form of teacher collaboration and reflection upon practice has been around for a century.

While it is widely accepted that the goal of a PLC is to change the culture of a school, (Francis & Jacobsen 2013, Riveros, Newton & Burgess, 2012, Wells & Feun, 2012), there can be many different objectives from one school to another. A PLC can have the goal of improved student achievement, but that may be envisioned in a PLC that simply focuses on shared materials, cross grade level articulation, best practices and pedagogy, or assessment (Wells & Feun, 2012). Regardless of the structure or focus of the PLC, Gregson and Sturko noted in their 2007 case study that PLCs need to address the issues of adult learners. They concluded that successful PLCs shared the following principles: 1.) Create a climate of respect, 2.) Encourage active participation, 3.) Build on experience, 4.) Employ collaborative inquiry, 5.) Learn for immediate application and, 6.) Empower through reflection and action.

These principles were echoed by Fulton and Britton in their 2011 summary of a two year National Science Foundation study that looked at STEM education and teaching. They noted that successful PLCs all met the following criteria: 1.) shared values and goals, 2.) leadership support, 3.) time, 4.) use of student data and work, 5.) collective responsibility, 6.) good facilitator, 7.) trust and, 8.) a single school subject. The concepts of leadership and mutual respect were further investigated by Wells and Feun in 2012 in their study of two middle school PLCs in different districts with similar demographics. They found that teacher buy-in is compromised when the agenda is set from the top, or district and administration level, down. In order for success teachers must start with the goal of what needs to be improved and be willing and committed to change, but also must work within the confines of the situational institution (Riveros, Newton & Burgess, 2012).

Other structural challenges can also impede the success of a PLC. In rural Canada, teachers from a variety of schools were too far from each other to meet in person and turned to a synchronous on-line format in which participants met via the internet (Francis & Jacobsen, 2013). The purpose of the PLC was to have teachers learn new methods for delivering math content and experience these strategies as students themselves. Unfortunately, Francis and Jacobsen found that the initial session was plagued with technical issues and many participants, unable to access the session due to incorrect log-in info, firewalls, non-functional microphones, and other issues, gave up and never returned to the PLC. The participants in “District A”, in the 2012 study conducted by Wells and Feun, also experienced frustration. Unlike their counterparts in the other district, they were asked to look at student achievement and assessment, but were given no specific tools by which to accomplish this task. Teachers in the "District B" reported a level of success in part due to the data analyzing computer program supplied by the district.

Engagement

While research indicates that professional development can improve teacher self-efficacy in the STEM subject areas, it is more interesting to note that engagement in the subject area is a better indicator of learning outcomes (Lau & Roeser, 2007). In a quantitative study based on the Achievement Goal Theory by Carolyn Dweck, researchers looked at the motivational processes affecting learning in high school students in math (Lau & Roeser, 2007). Results indicated that, for both boys and girls, ability was less of a factor in achievement than the perceived value of the goal (Lau & Roeser, 2007). Eric Geimer (2014) echoes these findings in his literature review on *The Efficacy of Mathematics Education*. He notes that the scores on standardized mathematics tests for American youth are significantly lagging behind other industrialized nations and this is attributed to unengaging instruction leading to a reduced level of interest in the subject (Geimer, 2014). Additionally, like students, teachers submitting to professional development need to feel engaged in their learning. Teachers' lack of science content knowledge and pedagogy can lead to strongly resisting the adoption of new curriculum (Symington & Fensham, 1976). One answer to the issue of engagement in STEM curriculum is arts integration (Geimer, 2014).

Arts Integration

How to integrate the arts into education has been the focus of much research and debate (Gullatt, 2008). Bresler, summarized four distinct approaches utilized in the field of education: the subservient approach in which the arts become merely crafts and musical songs designed to support the main curriculum; the co-equal, cognitive integration style in which the critical reflection of art and its historical perspective leads to higher order thinking skills needed to approach problem solving in all areas; the affective style in which the focus is on the appreciation of art forms and their mood altering qualities; and the social integration style in which performances and exhibitions become a unifying factor within the community (Bresler, 1995). Bresler posited that each of these integration styles had unique value and were usually seen in some combination at schools (Bresler, 1995).

Teachers appreciated the affective style of integration for its ability to build students' self-esteem by offering different entry points into curriculum and expression that might otherwise be closed due to poor reading, writing, or communication styles (Bresler, 1995). This idea is echoed for pre-service teachers as well. Exploratory research of math anxious, pre-service teachers found that providing an integrated music and math lesson improved the teachers' attitudes toward math, increased engagement, reduced anxiety, and ultimately led to higher confidence levels when it came to teaching math concepts (An, Ma, & Capraro, 2011).

While the affective approach to arts integration provides an engaging entry point for students and teachers who might otherwise experience anxiety in STEM fields, the co-equal, cognitive integration style most closely parallels the problem solving and higher-level thinking skills required by STEM curriculum (Nichols & Stephens, 2013). In the scientific method students are required to ask questions, make observations, and work collaboratively to execute investigations. These same higher level thinking skills are utilized when students work collaboratively to create visual art, develop theatrical productions, choreograph dance numbers, and compose music (Bresler, 1995; Gullatt, 2008; Nichols & Stephens, 2013).

The cognitive skills mirrored in STEM and the arts are also reflected in mathematics. In one study, teachers were introduced to a program that integrated the understanding of fractions with the development of music (Jones & Pearson, 2013). Not only were the students highly engaged through listening to current artists such as Justin Bieber and Miley Cyrus, but the execution of fractional bar music invited advanced algebraic thinking and could be differentiated in its presentation for different grade levels (Jones & Pearson, 2013). The need for engaging lessons in complex algebraic thinking and fractions was the number one concern for teachers in the Midwest as that is where students score most poorly on standardized tests (Bostic & Matney, 2013). The cognitive skills developed in arts curriculum have been shown to increase test scores (Aprill, 2001). While investigating the connection between arts integration and test scores in a Chicago school district, Aprill found that, while there is no direct transfer of content, “it is the interaction of and translation between the arts and language and mathematics as symbol systems, the mediating between different domains of knowledge which generates the learning as authentic intellectual work” (Aprill, 2001, p. 26).

CHAPTER THREE

Methodology

As I embarked upon this graduate project, several questions and theories guided its development. The staff at our school has expressed an appreciation for and its experience with the arts as we voted to become an arts charter in 2012. By integrating arts into STEM curriculum, would the staff be more likely to develop and teach STEM curriculum? In addition, over the past two years the staff have been subjected to approximately ten to twelve Common Core professional developments that were hastily created by our district and poorly implemented at the school level. Teachers have left these meetings feeling either confused, frustrated, or disinterested in the subject. Does the structure and development of the professional development make a difference in the teachers' level of engagement and ultimately in their future implementation? Finally, what strategies are needed to empower teachers to spend time developing and implementing curriculum?

Castlebay Lane Charter Elementary School is located in Porter Ranch, California. It is nestled in the foothills of the San Fernando Valley and services over 800 students. The students come from relatively affluent homes ranging in value from $450, 000 to over $2,000,000. According to Realtor.com the median income is $108,292. According to Los Angeles Unified School District (LAUSD) enrollment statistics for the most recently published school year of 2011-2012, Castlebay Lane comprises 38.6% Asian, 4.9% Filipino, 3.5% black, 9.6% Hispanic, and 43.4% white students. These students come from homes where over thirty different languages are spoken from English, Armenian, Korean, Tagalog, Mandarin, Vietnamese, Spanish, and Russian just to name a few.

Despite the numerous languages spoken only 5.2% of the students are classified as English language development (ELD). Castlebay Lane does not qualify for Title I and so a large portion of financial resources (approximately $180,000) are raised by our Parents and Teachers Helping (PATH) organization.

When looking at our school website one can see that PATH funds arts instruction above and beyond the arts instruction we already receive through the LAUSD Arts Prototype Program. While teachers at some schools may feel intimidated by arts instruction, our staff previously demonstrated a proclivity toward arts instruction as we became an affiliated charter in 2012 and stated in our charter that music, dance, art, theater, and technology shall be infused into the curriculum. Conversely, the staff at Castlebay Lane have expressed an aversion to teaching science as we overwhelmingly voted to create a science lab and hire a science specialist to teach all classes. While this endeavor has increased the exposure all students at Castlebay have to science curriculum, the size of our school creates scheduling issues such that no class can complete grade level appropriate science curriculum in the lab alone. This combined parent and teacher focus on the arts became the foundation for my arts and STEM integrated project.

In addition, the demographics at this school represent a high percentage of female to male teachers (twenty-eight female and three male). This ratio is generally reflective of the overall distribution of elementary (K-5) teachers in the United States (Feistritzer, Griffin, & Linnajarvi, 2011). The distribution of teachers in the grade levels is as follows: kindergarten-seven female; first grade-six female; second grade-six female; third grade-five female; fourth grade-two female and one male; fifth grade-one female and two male; and a four-five split-one female. The gender distribution of our staff is important.

According to the National Girls Collaborative Project 47% of the American workforce comprises women yet far fewer are represented in the STEM fields. This male dominated imbalance is particularly noticeable in the field of engineering where women represent only 13%. It, therefore becomes incumbent upon female teachers to adopt a more positive attitude towards and better pedagogy for STEM instruction.

Project Goals and Objectives

The over-arching goal of this graduate project was to assess the underlying reasons why teachers at Castlebay Lane are not actively developing and teaching integrated STEM lessons and units. After determining what possible obstacles hinder our staff from providing this essential curriculum to our students, such as anxiety regarding STEM, time constraints, and/or poorly designed professional developments, I created this project with several specific objectives. First, I wanted to inform my staff about the importance of STEM education to the future of our nation and its benefits in promoting problem solving thinking in students. Second, I wanted to provide my staff with an example of an arts integrated STEM unit for the fourth grade. Third, I wanted to demonstrate to my staff best practices in pedagogy. Fourth, given the time constraints placed on myself by the school, I wanted to provide an ongoing support system in the form of a professional learning community (PLC). Finally, I wanted to accomplish all of these in an engaging P.D. that would ultimately inspire teachers to meet the main goal of teaching STEM.

As I prepared for this project I wanted to get some feedback regarding the STEM anxiety levels of the teachers prior to the in-service. I used a modified version of the quantitative R-MANX (Revised Math Anxiety Instrument) survey, verified by Bursal and

Pasnokas (2006) in their research. The original anxiety survey was developed and administered to pre-service teachers and I omitted or modified questions that do not apply to practicing teachers. The questionnaire I developed also took inspiration from the STEBI (Science Teachers' Efficacy Belief Instrument), and MTEBI (Math Teachers' Efficacy Belief Instrument) surveys verified in research undertaken by Enochs among others. In their study, all teachers answered questions about the application of mathematical and scientific concepts in daily life and in the classroom to determine the level of mathematical and scientific anxiety (Enochs, Smith, & Huinker, 2000; Riggs & Enochs, 1990). My questionnaire used a Likert scale of one to five to determine how teachers felt about concepts such as their own content knowledge, their ability to answer students' questions, their knowledge of accepted pedagogy in a particular field, etc. Teachers were also asked to identify themselves as being more comfortable with STEM concepts or arts concepts.

In addition, another questionnaire was administered to gather general background information on the teachers such as age, years of teaching experience, method of credential acquisition, and obligations outside of school. The method of credential acquisition was of particular interest as research shows a rise in the number of teachers obtaining credentials through alternative methods (Feistritzer et al., 2011). I was also credentialed through an alternative method and so my undergraduate degree is in the history of art as opposed to an education degree. This questionnaire also addressed other possible issues that might affect a teacher's ability to put time into lesson planning other than interest in the lesson design (Johnson, 2007).

All teachers at Castlebay Lane attended a two hour professional development (P.D.) session that highlighted the importance of STEM curriculum and then provided specific instruction on how to develop lessons that integrate arts with math (Jones & Pearson, 2013). This P.D. was presented during the regularly scheduled Tuesday release time. I provided grade level appropriate support to all participating teachers in developing these lesson plans if they requested assistance and scheduled a time outside of regularly scheduled school hours. The explicitly integrated fourth grade lessons developed drew from the math standards in the CA Common Core, the NGSS (Next Generation Science Standards) which encompass science and engineering standards, and the CA Standards for the Visual and Performing Arts (VAPA). After several weeks, I followed up with teachers to discuss concerns about implementation and offered additional information on arts integration drawn from previously researched and successful programs (Jones & Pearson, 2013).

CHAPTER FOUR

Chapter four is organized into several sections: 1.) a discussion of the feedback from the questionnaires administered prior to the P.D. and their effect on the P.D.'s design, 2.) an overview of the integrated unit for fourth grade, 3.) an overview of the actual P.D., 4.) a discussion of how teachers were informed about the importance of STEM while experiencing best practices in pedagogy, and finally, 5.) a discussion of PLCs.

Pre Professional Development Questionnaire Feedback

As I developed and prepared for this P.D., I needed to gain some insight into the teachers' attitudes about math and science, their understanding of how to develop an arts integrated lesson, and their familiarity with the newly adopted Common Core ELA and math standards as well as the soon to be adopted Next Generation Science Standards (NGSS). Significant research exists supporting the idea that many teachers experience anxiety in the math and science areas and I wanted to know if this held true with my own staff. In addition, it was important to gage how clearly Castlebay's teachers understood Common Core math standards and NGSS. I asked teachers to complete several questionnaires one week prior to the P.D. Of the thirty three teachers who received the questionnaires, only eleven were returned to me.

I took the R-Manx survey which was developed by Bursal and verified through his research and modified the questions to reflect the fact that my staff are practicing teachers as opposed to the pre-service teachers for which the survey was originally designed. I also rephrased some questions about math attitudes to reflect attitudes about science. The results were quite inconclusive. The questionnaires were fairly evenly split across the spectrum with some teachers experiencing some level of math and science anxiety, to general indifference, to a high level of comfort with the subjects. Of the eleven questionnaires returned to me the undergraduate degrees were held primarily in the liberal arts or English and theater, while only two teachers had degrees in accounting and economics. Teachers also failed to conclusively identify themselves as either an arts person or a math and science person. As math and science anxiety was not a focal concern, I turned my attention more towards attitudes regarding Common Core math and the NGSS.

As I have previously alluded to, I was very disappointed with the number of questionnaires returned to me and generally they did not confirm a theory about math and science anxiety. However, the survey results did shed some light on attitudes regarding Common Core math and the issue of time. Over the last several years teachers have attended anywhere between zero, to four or five, to "too many" trainings on Common Core math. The comments made on the surveys indicate that they understand Common Core math puts a focus on math practices and explanation of problem solving. Interestingly, of the eleven questionnaires that were returned, even they were not always completed. Perhaps the length of the questionnaires was too much. One question asked, "Do you feel there is enough time in the day to implement curriculum as it has been presented to you?" Here all of the questionnaires had a response of "no." It is quite telling that even when a teacher did not answer any other questions on the questionnaire, they still wanted their voice to be heard on the issue of time.

When asked if they enjoyed teaching Common Core math, the responses were also varied. One teachers stated, “Only if appropriate materials and time allowing it,” are provided. Teachers were also divided when it came to believing whether their students enjoyed Common Core math based on level of engagement. To be divided on the issue of student engagement is not acceptable. Every student should be engaged in their learning and every teacher should project a strong level of enthusiasm for their teaching.

The final piece of information gained form the questionnaires was teachers’ understanding of and familiarity with the NGSS. Here there was a unanimous response that teachers were not familiar with these standards. One teacher even went so far as to write in that the NGSS are, “not adopted yet” illustrating that the staff has not been made aware that the state of California adopted the NGSS after the final version was released on April 9, 2013. So, while math and science anxiety are not necessarily factors in why teachers are not fully implementing STEM integrated units of study, the issue of time seems to be a major factor. With these issues in mind I developed the following unit of study for fourth grade as an exemplar of how teachers might develop their own units of study that are both time saving from the point of view of scheduling and engaging for both teacher and students.

Scope and Sequence of an Arts and STEM Integrated Unit

To meet my second objective of providing my staff with an integrated unit of study that would serve as an exemplar I developed a five week unit based on ocean science and sea turtles. As time was a central issue to teachers, I created a completely original arts integrated unit of study that would address a variety of standards simultaneously. The purpose of Common Core is to develop critical thinking skills in our students so they can compete in an ever-changing global economy and be able to solve some of the many problems facing our planet. With this in mind, I first brainstormed some of the possible global issues such as climate change, drought, ocean health, energy resources, and so on. As I wanted this P.D. to be appealing to all teachers, and for all grade level teachers to see the potential connection this unit might have in their own classrooms, I chose the ocean.

The next key component in the development of this unit was the belief that the NGSS should be the central focus of the unit while Common Core ELA and math standards would supplement each of the lessons. Students would use evidence from text and web-based sources and math skills and concepts to support and elaborate their work in science and engineering standards. The arts would be taught and woven through some of the lessons as a means for students to extend and express their understanding of the NGSS and of specific skills form VAPA. In addition the arts integration would increase the engagement level of both students and teachers.

The unit of study developed follows the BSCS 5E instructional model. In this model there are five steps to the lesson plan which are engage, explore, explain, extend, and evaluate (Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Powell, J., Westbrook, A., & Landes, N., 2006). According to Bybee et. al. the purpose of the engage phase is to elicit curiosity and assess prior knowledge. The explore phase allows the students to develop a common base of knowledge from which new concepts can be developed. The teacher may introduce explicit instruction and key vocabulary during the explain phase and students can then demonstrate their new found understanding of the concepts. During the extend phase students are provided with opportunities to apply their newfound understandings to different activities. Finally, the evaluate phase gives the students and teacher an opportunity to assess their progress towards the learning objectives. Bybee et. al.in 2006 noted that this learning format works for both an individual lesson as well as a full integrated unit of study.

The two hour P.D. would be my opportunity to share this unit and its structure with my staff. Keeping the teachers fully engaged during the P.D. was my primary focus so the actual lesson plans for the entire unit were made available to the fourth grade following the P.D. Figure 1 shows a power point slide from the P.D. that illustrated to teachers the name of each lesson, which set of standards (Common Core ELA or math, NGSS, and/or VAPA) were addressed by each lesson, and the genre of performing arts (visual, music, theater, or dance) that would be included. The integration of arts and STEM with the 5E model promotes maximum rigor and problem solving.

Figure 1. Power-point slide of Sea Turtle Ocean Unit scope and sequence as presented to teachers at the P.D.

Figure 2. Suggested timeline for the Sea Turtle and Ocean Unit

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	**Lesson 1** Loggerhead Sea Turtle Fractions, Geometry, and Ceramics Engage (10 min.) Explore (50 Min.)	**Lesson 1** Loggerhead Sea Turtle Fractions, Geometry, and Ceramics Explain (30 min.) Extend (30 min)	**Lesson 1** Loggerhead Sea Turtle Fractions, Geometry, and Ceramics Evaluate (50 min.)	**Lesson1** Loggerhead Sea Turtle Fractions, Geometry, and Ceramics Evaluate (50 min.)	**Lesson 1** Wrap-up
Week 2	**2 Lesson** Sea Turtle Life Cycle, Migration, and Dance Engage (15 min.) Explore (50 min.)	**Lesson 2** Sea Turtle Life Cycle, Migration, and Dance Explore (50 min.)	**Lesson 2** Sea Turtle Life Cycle, Migration, and Dance Explain (50 min.)	**Lesson 2** Sea Turtle Life Cycle, Migration, and Dance Explain (50 min.)	**Lesson 2** Sea Turtle Life Cycle, Migration, and Dance Extend (50 min.) optional
Week 3	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Engage (50 min.)	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Explore (50 min.)	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Explore (50 min.)	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Explain (50 min.)	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Explain (50 min.)
Week 4	**Lesson 3** Sea Turtle Survival vs. Energy Consumption Evaluation/Presentations (50 min.) Extend (50 min.) optional	**Lesson 3** Extend (50 min.) optional **Lesson 4** Loggerhead TEDs and Engineering Engage (15 min.)	**Lesson 4** Loggerhead TEDs and Engineering Explore (50 min.)	**Lesson 4** Loggerhead TEDs and Engineering Explore (50 min.)	**Lesson 4** Loggerhead TEDs and Engineering Explore (50 min.)
Week 5	**Lesson 4** Loggerhead TEDs and Engineering Explore (50 min.)	**Lesson 4** Loggerhead TEDs and Engineering Extend (50 min.) optional	**Lesson 4** Loggerhead TEDs and Engineering Extend (50 min.) optional		

A more detailed account of exactly how much time each section of the 5E lesson plan would take and when it could be delivered is illustrated in Figure 2. In the following pages I have included a complete set of lessons with specific standards addressed and activities for each stage of the 5E lesson plan. Also included are grading rubrics for teachers to assist in assessment. It is worth noting that each lesson requires cooperative learning and has a mechanism for peers to assess each other. I have not included lesson 1 in this section as it is included in the discussion of the actual P.D. and how the lesson was experienced by the teachers.

Lesson 2: Sea Turtle Life Cycle, Migration, and Dance

Objectives: Students will be able to:

- Choreograph a short dance sequence in sets of eight beats using low, medium, and high levels
- Express through dance movements the predators and obstacles sea turtles face
- Interpret and express the life cycle of a sea turtle through dance movements

Standards: NGSS

4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

VAPA

2.0 Creative Expression: Creating, Performing, and Participating in Dance

Students apply choreographic principles, processes, and skills to create and communicate meaning through the improvisation, composition, and performance of dance.

2.1Creation/Invention of Dance Movements: Create, develop, and memorize set movement patterns and sequences.

Common Core ELA

Literacy .L.4.3.A: Choose words and phrases to convey ideas precisely.*

L.4.6: Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).

Engage: (15 minutes)

Students will watch a brief video of a sea turtle's life cycle and migration patterns at http://www.animalplanet.com/tv-shows/other/videos/fooled-by-nature-turtle-navigators/

Explore: (2 – 50 minute sessions)

Students will read an article from NOAA's National Marine Fisheries Service, Office of Protected Resources in The Kid's Times: Volume I, Issue 3 Leatherback Sea Turtle at http://www.nmfs.noaa.gov/pr/pdfs/education/kids_times_turtle_leatherback.pdf

After reading the article students will break into groups of four and list the stages of a sea turtles life, its predators, and migration patterns. Teacher will demonstrate possible dance movements within a high, medium, and low spatial level. Students will discuss the appropriate level and dance movement to express six elements of the sea turtles' life cycle and migration patterns.

Explain: (2 – 50 minute sessions)

Students will choose an appropriate musical piece from teacher provided selections and develop a unified dance that expresses each phase of the life cycle with a unique dance movement. The six sets of eight will be repeated twice by all members of the group. Students will write a description of each dance movement and how it reflects the migration, eating habits, or predators of the sea turtle.

Extend: (50 minutes)

Students can alter the dance sequence by having a larger group of six to eight students choreograph two sets of movements that express the migration, life cycle events, and predators of the sea turtle in a call and response format.

Evaluate:

Students will be assessed according to the following rubric:

4 Students demonstrate all criteria for a 3 and develop additional dance movements representing more elements of the life cycle. Students perform with attention to facial expression.	**3** Students create six distinct movements that express an element of the sea turtles life cycle, migration patterns, and predators. Choreography had movements in each of the three spatial dance levels. Students performed in unison with each other.	**2** Students develop fewer than six distinct dance movements or dance movements do not clearly reflect the life cycle, migration, or predators. Individual students are not in unison with group. Students only develop movement for two of the three spatial levels.	**1** Students' dance movements are indistinct and reflect only one spatial level. Students do not dance in unison and/or forget movements.

Lesson 3: Sea Turtle Survival vs. Energy Consumption Theatrical Dialogue in a PSA

Objectives: Students will be able to:

- Conduct focused research from several resources
- Develop a script with a target audience and specific message
- List the effects of climate change on sea turtle habitats
- Express character emotions in a theatrical presentation

Standards: NGSS

4-ESS3-1**:** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

VAPA

2.0 Creative Expression: Creating, Performing, and Participating in Theatre Students apply processes and skills in acting, directing, designing, and scriptwriting to create formal and informal theatre, film/videos, and electronic media productions and to perform in them. Development of Theatrical Skills

2.1 Demonstrate the emotional traits of a character through gesture and action. Creation/Invention in Theatre

2.2 Retell or improvise stories from classroom literature in a variety of tones (gossipy, sorrowful, comic, frightened, joyful, sarcastic).

2.3 Design or create costumes, props, makeup, or masks to communicate a character in formal or informal performances.

Engage: (50 minutes)

Students will watch several public service announcements (PSAs) created for ocean health at

https://www.youtube.com/watch?v=tKtl15UJqRA

https://www.youtube.com/watch?v=7Fflz7uncew

https://vimeo.com/107839139

Teacher will facilitate a class discussion about the structure of a PSA. Is there a statement of problem? What images are shown to illustrate the point? Are solutions offered? Teacher will then turn students' attention to the idea that energy consumption has an effect on climate change which has an effect on sea turtle habitats.

Explore: (2 – 50 minute sessions)

Students will read several articles that discuss the effect that climate change is having on sea turtles. Students will list the types of energy consumption that effect climate change and the specific types of sea turtle habitat destruction. The articles are found at:

http://www.conserveturtles.org/seaturtleinformation.php?page=climate_change

http://www.worldwildlife.org/threats/effects-of-climate-change http://www.neaq.org/conservation_and_research/climate_change/effects_on_ocean_animals.php

Teacher will place students in groups of four to conduct research.

Explain: (2 – 50 minute sessions)

Students will develop a one minute PSA about the effects of energy consumption on sea turtle habitats. Students will write a script with the targeted audience being other students and the solution being what students can do to reduce energy consumption. Each member of the team must develop a character with costume and perform their part of the PSA in character using facial expressions and appropriate body language. Each PSA must include one form of energy consumption and one form of habitat destruction and one solution.

Extend: (2 – 50 minute sessions)

Students can develop an interview scenario in which a journalist interviews different people about energy consumption and the destruction of sea turtle habitats. Students may film their interview and add appropriate music.

Evaluate: (50 minutes)

Students will be evaluated using the following rubric:

	Theater Objectives	Science Content Objectives	Peer Cooperation Objectives
4	Student does everything for a 3 and demonstrates creativity in character choice that is exceptionally memorable.	PSA does everything for a 3, and includes more than one solution.	Student does everything for a 3, and demonstrates leadership skills in guiding the team to decisions.
3	Student creates a character that is clearly defined as human or animal and utilizes costume elements that express the character. Student develops a voice and body movements that are consistently applied throughout the PSA.	PSA includes one clearly defined source of energy, one clearly defined destruction of habitat, and one clearly defined solution.	Student works cooperatively with team while taking notes on the readings and making suggestions as to which energy source, habitat destruction, and solution should be chosen for the PSA.
2	Character development lacks either a voice, costume, or body movements	PSA fails to clearly develop one of the three objectives of energy source, habitat destruction, and solution.	Student works with team, but fails to contribute ideas or constructively debate the pros and cons of other team member ideas.
1	Student’s character is no different from everyday behavior and mannerisms.	PSA only includes one of the three elements.	Student is argumentative and disruptive to the cooperative process.

Lesson 4: Loggerhead Turtle Excluder Devices (TEDs) and Engineering

Objectives: Students will be able to:

- Identify opportunities in the life sciences for engineering
- Work through the engineering design process with a team
- Communicate ideas through words and illustrations
- Design a contraption that can catch and extrude different sized balls

Standards: NGSS

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

VAPA

2.0 Creative Expression: Creating, Performing, and Participating in the Visual Arts Students apply artistic processes and skills, using a variety of media to communicate meaning and intent in original works of art. Skills, Processes, Materials, and Tools

2.1: Use shading (value) to transform a two-dimensional shape into what appears to be a three-dimensional form (e.g., circle to sphere).

Common Core ELA

Literacy.L.4.3.A: Choose words and phrases to convey ideas precisely.*

L.4.6: Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).

Engage: (15 minutes)

Students will watch a video by NOAA about the development of a sea turtle excluder net also known as a TED (turtle excluder device). The students will learn how sea turtles can die when they are inadvertently caught in fishing nets designed for other fish. They will see how biologists and engineers worked together to understand the behavior of sea turtles and how a net could be developed that would allow smaller fish to be caught and sea turtles to escape.

http://oceantoday.noaa.gov/savingseaturtles/

Explore: (4 – 50 minute sessions)

Teacher will introduce the NASA engineering design process of stating the problem and understanding criteria and constraints, brainstorming ideas, developing a single idea, building the prototype, testing the prototype, and redesigning. Teacher will then explain that the design challenge is to build a contraption from recycled materials that can stand independently and sort different sized balls (marbles and ping pong balls) into separate departments. Students will be placed into groups of four to work through the design process. Students will also be instructed to work cooperatively as they will grade their peers.

Explain:

Students' journals will be completed with detailed drawings of their independent ideas and the chosen group idea. Students will write sentences in their journals explaining the pros and cons of each of the considered ideas.

Extend: (2 – 50 minute sessions)

Students can design an additional ball sorter that sorts three or more differently sized balls. Students can "purchase" recycled materials to develop their designs thereby working within the constraint of a budget.

Evaluate:

Students will be evaluated with the following rubric:

	Journal Completion	Presentation	Peer Review
4	I completed four or more independent brainstorm ideas and made three or more constructive comments or questions about each of my teammates' ideas. All pages of my journal are complete.	I completed my journal with outstanding precision and made very detailed illustrations.	I did everything to earn a three and showed leadership skills in helping our team stay on task and work through disagreements.
3	I completed three independent brainstorm ideas and made two constructive comments or questions about each of my teammates' ideas. All pages of my	I completed my journal in legible writing and used color where appropriate in my illustrations.	I worked cooperatively with my team members by suggesting ideas and evaluating others' ideas in an appropriate way. I did my job and let others do theirs.

	journal are complete.		
2	My journal pages are incomplete. I did not write two comments for each teammate. I only have two brainstorm ideas.	My writing is legible, but somewhat sloppy and my illustrations are not clear.	I worked cooperatively with my team, but did not offer any ideas or constructive criticism.
1	My journal pages are incomplete. I did not write any comments for each teammate. I only have one or no brainstorm ideas.	My writing is illegible and my illustrations cannot be understood by other members of my team.	I failed to complete my assigned tasks and argued with team members instead of working towards a group solution.

Professional Development Content for Teachers

In order to meet my first objective, which was to inform my staff about the importance of STEM education, and to share the ocean unit with my staff, I now turned my attention to the two hour P.D. Paramount to the success of reaching the main goal of having a school where arts integrated STEM lessons are taught on a regular basis, the P.D. needed to impart critical background information, demonstrate best practices, be inspirational and engaging, and provide for some sort of planning. The P.D.s that some of our staff members had attended on Common Core generally consisted of a presenter passing out a stack of written materials and then reading them to us or having us read sections and then sharing out. This type of P.D. is not appreciated by our staff, nor can many teachers share what they learned within several hours. In addition, the information was not put into a format that teachers could easily take back to their classrooms and start implementing.

Therefore, I designed my P.D. to use simple visuals in the form of a power point to highlight key concepts, and to provide teachers with an opportunity to develop their own understanding as we went through the presentation. This section of the P.D. was to last no more than ten minutes. The following pages represent the general script of this introduction.

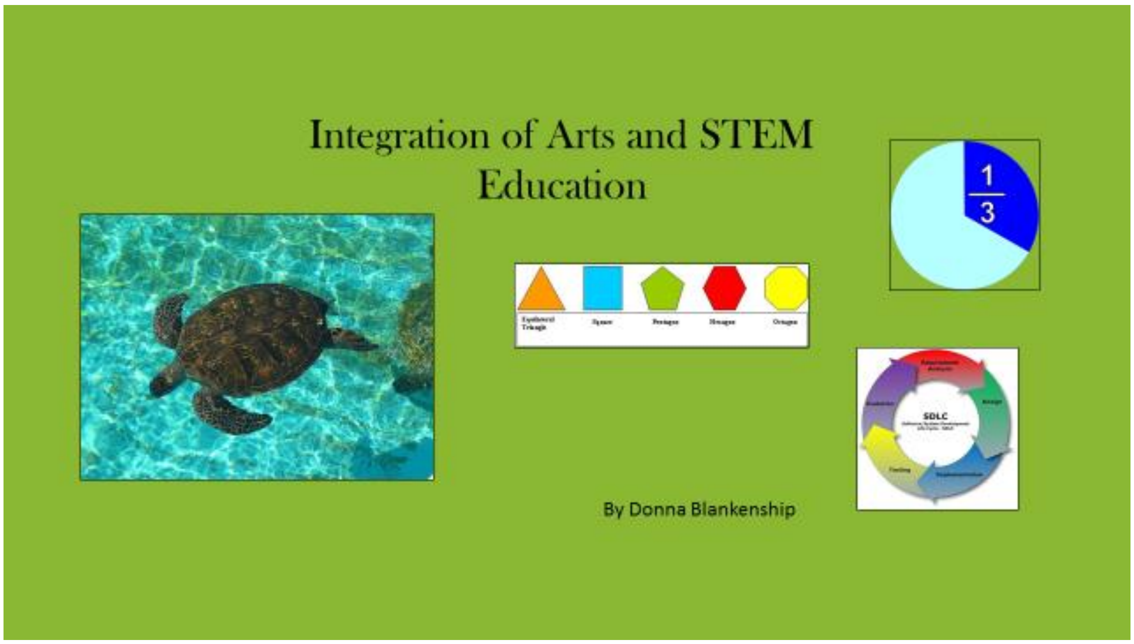

Figure 3. Opening slide of the Power-point presentation in a simple and bright format

As we enter into the twenty-first century, our American education system must develop students prepared to fill the ever increasing number of STEM (science, technology, engineering, and math) careers. According to Langdon, McKittrick, Beede, Beethika, & Doms in 2011 many U.S. businesses are expressing concern over the lack of qualified applicants in this country. Langdon et al. also note in their study that careers in the STEM fields are projected to grow at a staggering 17% between 2008 and 2018. This concern has not gone unnoticed by the Obama Administration which has created a committee on STEM education and is looking at current policies and programs (Committee on STEM Education National Science and Technology Council, 2011).

Geimer expresses concern in his 2014 study about the efficacy of mathematical instruction in this country. According to a Programme for International Student Assessment (PISA) study in 2012, research has shown that student performance on problem solving tests is only slightly above average compared with the results of other industrialized nations. Researchers such as Geimer in 2014, Jackson & Leffingwell in 1999, and Meece, Wigfield, & Eccles in 1990 note that there are myriad reasons why math instruction is ineffective including, but not limited to, math anxiety experienced by teachers and lack of engaging math instruction.

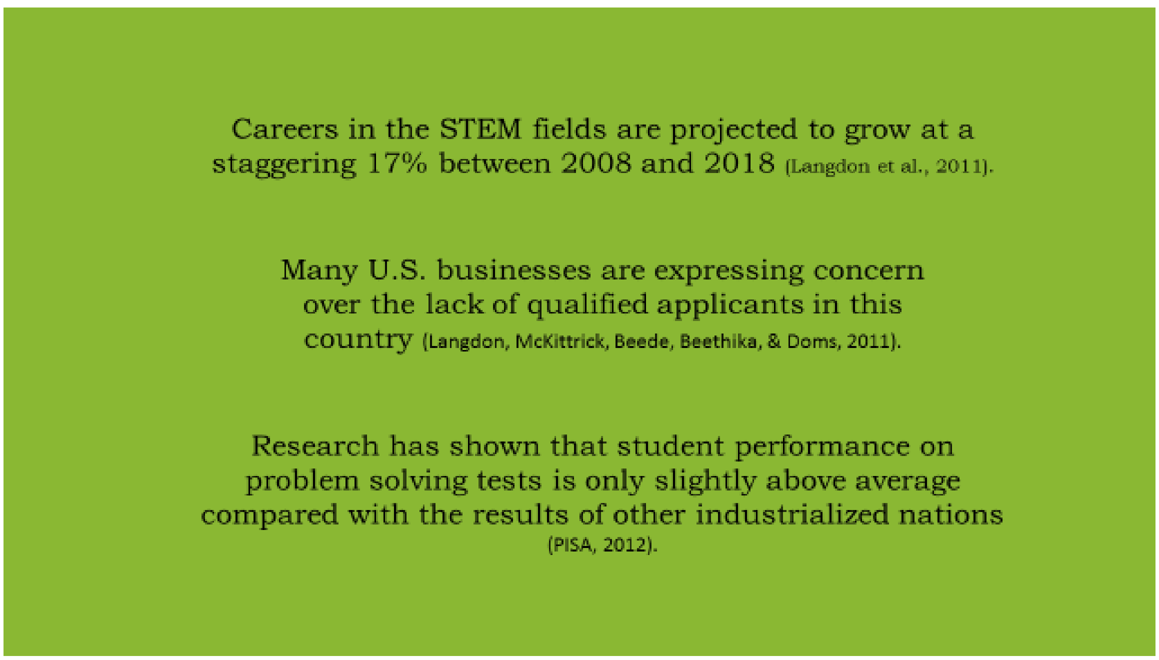

Figure 4. Slide highlighting key areas of concern in the United States

I challenge you to remember why you became a teacher and what you hope to accomplish with your students. In this time of changing standards we must remember that the purpose of the CCSS and NGSS is to meet the needs of our ever changing economy and planet with adults who can critically think and problem solve. There is no longer a need to memorize facts, data, and algorithms because all information is easily at our finger tips due to technology. We must now focus our attention on applying those pieces of information to problems.

As an American society we have a tremendous responsibility to be able to understand and critically analyze graphs and mathematical data, as well as scientific studies as we exercise our right to vote. This privilege is one that not all countries share. In the news we have several pressing issues under our control. The most current is vaccines. As measles, a once eradicated disease, spreads across the United States we are being asked to guide our lawmakers as to whether or not we should force all children to be immunized. I am not standing before you to express my opinion, but rather to ask, “Do we understand the research surrounding this issue and its methodology?” Other critical issues are global warming, the depletion of the oceans, and drought right here in our own backyard.

I would like to present a simple illustration of how important it is for our students to critically analyze mathematical data. We all know what elements should be present in a graph. I would like you to look at this graph published in our current *Treasures* language arts curriculum.

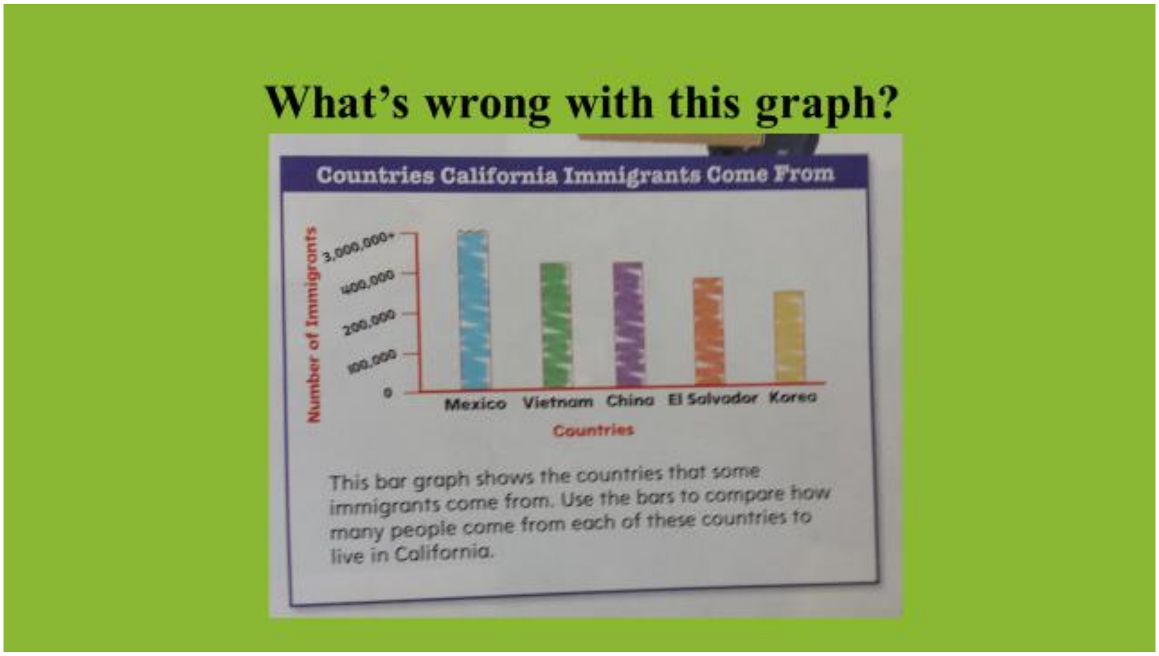

Figure 5. Slide illustrating published curriculum with an incorrectly formatted graph

Does anyone see anything mathematically incorrect about the presentation of data? What you will see here is that equally spaced intervals in the graph are not assigned equal numerical values. This skews the results of the graph making the number of immigrants from various cultures into California seem closer than it actually is. It also contradicts mathematical concepts that equal values are assigned equal space on a number line which is a second grade standard. In this same series I would like to draw your attention to this statement at the end of a lesson on writing directions with science integration. The statement says, "Gas does not take up space." Does this agree with your understanding of this science concept?

I am suggesting that we stop relying on hastily developed curriculums and apply our own critical thinking to developing lessons and units that truly meet the intent of the

CCSS and NGSS. By integrating arts into STEM subjects we can meet the Common Core and NGSS standards while simultaneously meeting visual and performing arts standards (VAPA). Creating integrated units will not only allow us to address all of these standards in a more time efficient manner, but I am suggesting that it will reduce our anxiety around STEM instruction as well as the anxiety experienced by our students. To begin an integrated unit of study, one can think of some global issues affecting our planet.

Figure 6. Slide illustrating several global concerns

Our job as teachers is to capture the imagination of our students and prepare them for the problem solving challenges of the future.

Figure 7. Slide aligning photographic images of nature with student created art

We can meet these needs by turning STEM into STEAM.

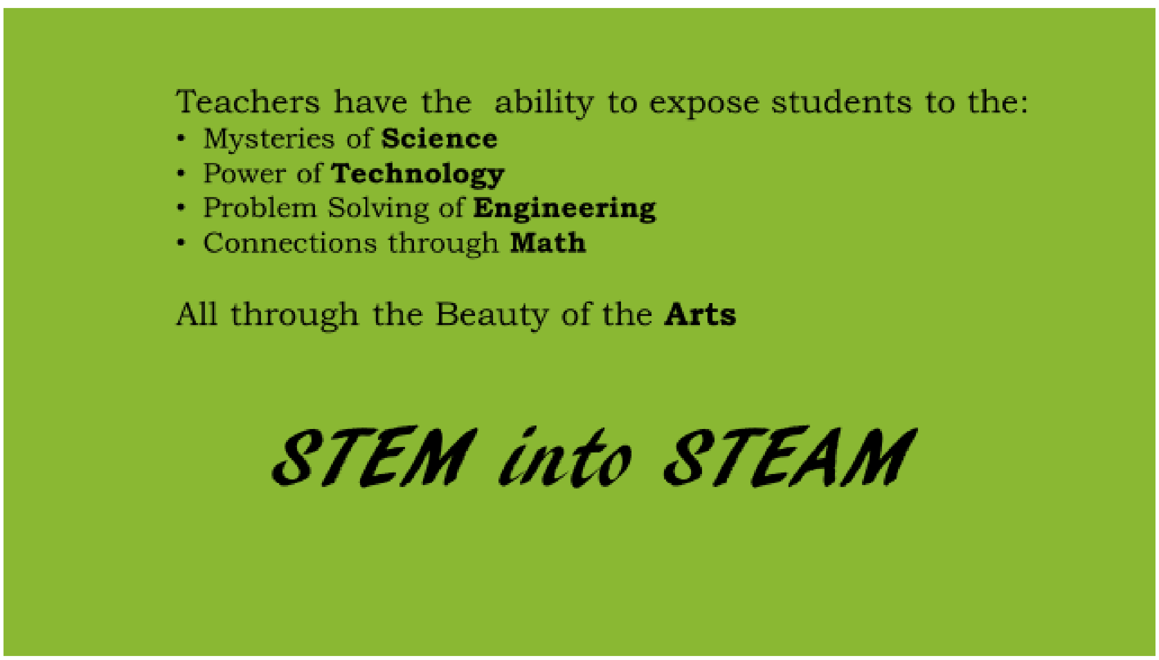

Figure 8. Slide introducing the terms in the acronyms STEM and STEAM

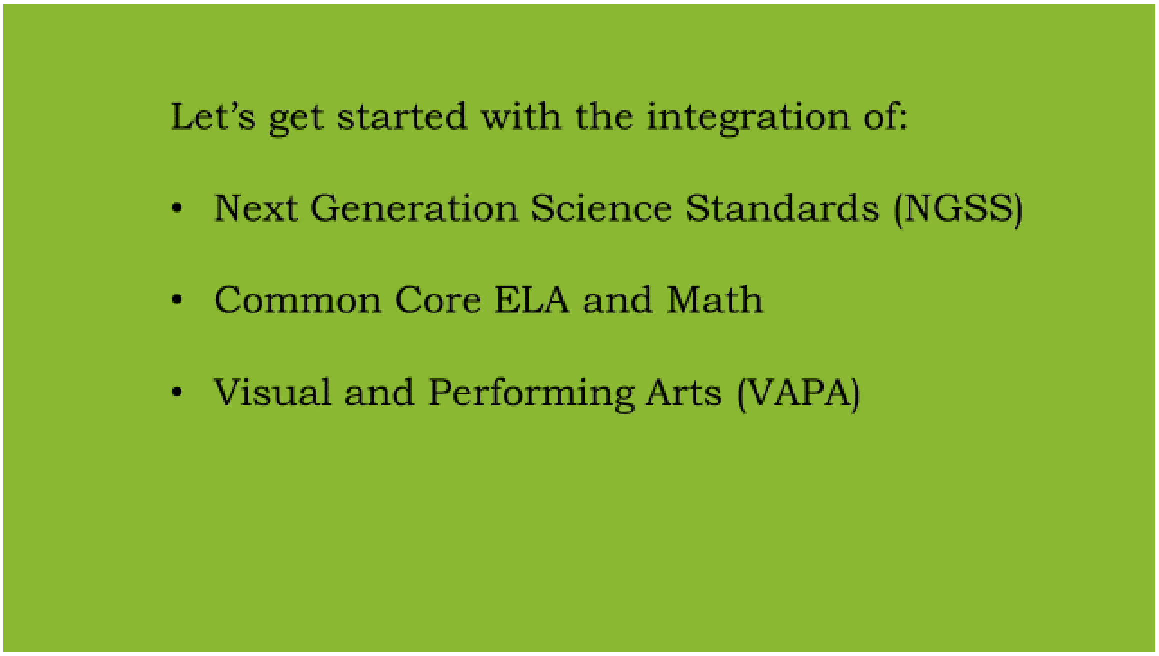

Figure 9. Slide listing all relevant standards

Best Practices

My third objective was to demonstrate best practices to my staff. This had partially been accomplished when the teachers had to explore the power point slide in which an erroneously formatted graph was presented. They had an opportunity to use their own background knowledge of math and graphing and discuss their understanding with colleagues. To continue having the teachers participate in best practices I introduced the first two steps of lesson 1: Loggerhead Sea Turtle Fractions, Geometry, and Ceramics. The lesson is also formatted after NASA's 5E model. The five "E"s stand for Engage, Explore, Explain, Extend, and Evaluate. This format is used by NASA and has also been adopted by some of the newer math curriculum being developed such as *Go Math* by Houghton Mifflin Harcourt. It was also noted by Bybee et. al. in their 2006 summary that there are over 73,000 instances in both printed and web based genres of the

5E model being used in textbooks, units, and modules. They also searched the World Wide Web and found 235,000 instances of the 5E model being used in individual lesson plans.

The lesson addresses many different standards from Common Core ELA and math, as well as VAPA. I have included the entire lesson as it was presented to the teachers.

Lesson 1: Loggerhead Sea Turtle Fractions, Geometry, and Ceramics

This lesson plan has the express intention of integrating standards and objectives from both the CCSS and VAPA standards.

Objectives: Students will be able to

- Review 3-Dimensional figures such as a cube, sphere and cylinder
- Identify geometric shapes such as hexagons, pentagons, and quadrilaterals in nature
- Identify the number and type (obtuse, acute, or right) of angles in various geometric shapes
- Identify the line of symmetry in a two-dimensional figure
- Express a geometric design through repeating patterns
- Model equivalent fractions and fraction relationships in clay
- Express equivalent fractions and fraction relationships abstractly
- Discuss shapes and fractions using correct mathematical vocabulary

- Apply ceramic art skills such as shaping and use of “slip”

Materials:

Pre-cut cubes of ceramic clay measuring approx... 8cm. x 8cm. x 8cm.

Wooden ceramic modelling tools

Access to the internet or preprinted images of loggerhead turtles

https://www.agapetile.com/products/images/Artistry%20In%20Mosaics%20237%20Lgrhd%20Turtle%20Brown%20Lg.jpg

http://upload.wikimedia.org/wikipedia/commons/1/13/Loggerhead_turtle.jpg

http://www.fishtaxidermist.com/turtle2.jpg

http://www.marinelife.org/view.image?Id=1052

Fractional ceramic worksheets that are laminated (Appendix E)

Wax pencils or overhead projector pens

http://marinebio.org/upload/chelonia-mydas/green-sea-turtle.gif

This link is to a scientific diagram of the loggerhead turtles’ shell/carapace (Appendix F)

Worksheets on fractions (Appendix H) and geometric shapes (Appendix G)

Standards addressed:

CCSS.MATH.CONTENT.4.G.A.1

Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

CCSS.MATH.CONTENT.4.G.A.3

Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.

CCSS.MATH.CONTENT.4.NF.A.1

Explain why a fraction a/b is equivalent to a fraction $(n \times a)/(n \times b)$ by using visual fraction models, with attention to how the number and size of the parts differ even though the two fractions themselves are the same size. Use this principle to recognize and generate equivalent fractions.

CCSS.MATH.CONTENT.4.NF.A.2

Compare two fractions with different numerators and different denominators, e.g., by creating common denominators or numerators, or by comparing to a benchmark fraction such as 1/2. Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with symbols >, =, or <, and justify the conclusions, e.g., by using a visual fraction model.

CCSS.MATH.CONTENT.4.NF.B.4.C

Solve word problems involving multiplication of a fraction by a whole number, e.g., by using visual fraction models and equations to represent the problem. For example, if each person at a party will eat 3/8 of a pound of roast beef, and there will be 5 people at the party, how many pounds of roast beef will be needed? Between what two whole numbers does your answer lie?

CCSS.ELA-LITERACY.L.4.3

Use knowledge of language and its conventions when writing, speaking, reading, or listening.

CCSS.ELA-LITERACY.L.4.3.A

Choose words and phrases to convey ideas precisely.*

CCSS.ELA-LITERACY.L.4.6

Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).

VAPA Standards

1.0 ARTISTIC PERCEPTION

Processing, Analyzing, and Responding to Sensory Information through the Language and Skills Unique to the Visual Arts

Students perceive and respond to works of art, objects in nature, events, and the environment. They also use the vocabulary of the visual arts to express their observations.

Analyze Art Elements and Principles of Design

1.5 Describe and analyze the elements of art (e.g., color, shape/form, line, texture, space, and value), emphasizing form, as they are used in works of art and found in the environment.

2.0 CREATIVE EXPRESSION

Creating, Performing, and Participating in the Visual Arts

Students apply artistic processes and skills, using a variety of media to communicate meaning and intent in original works of art.

Skills, Processes, Materials, and Tools

2.2 Use the conventions of facial and figure proportions in a figure study.

2.3 Use additive and subtractive processes in making simple sculptural forms.

5.0 CONNECTIONS, RELATIONSHIPS, APPLICATIONS

Connecting and Applying What Is Learned in the Visual Arts to Other Art Forms and Subject Areas and to Careers

Students apply what they learn in the visual arts across subject areas. They develop competencies and creative skills in problem solving, communication, and management of time and resources that contribute to lifelong learning and career skills. They also learn about careers in and related to the visual arts.

Connections and Applications

5.2 Identify through research twentieth-century artists who have incorporated symmetry as a part of their work and then create a work of art, using bilateral or radial symmetry.

ENGAGE (10 minutes)

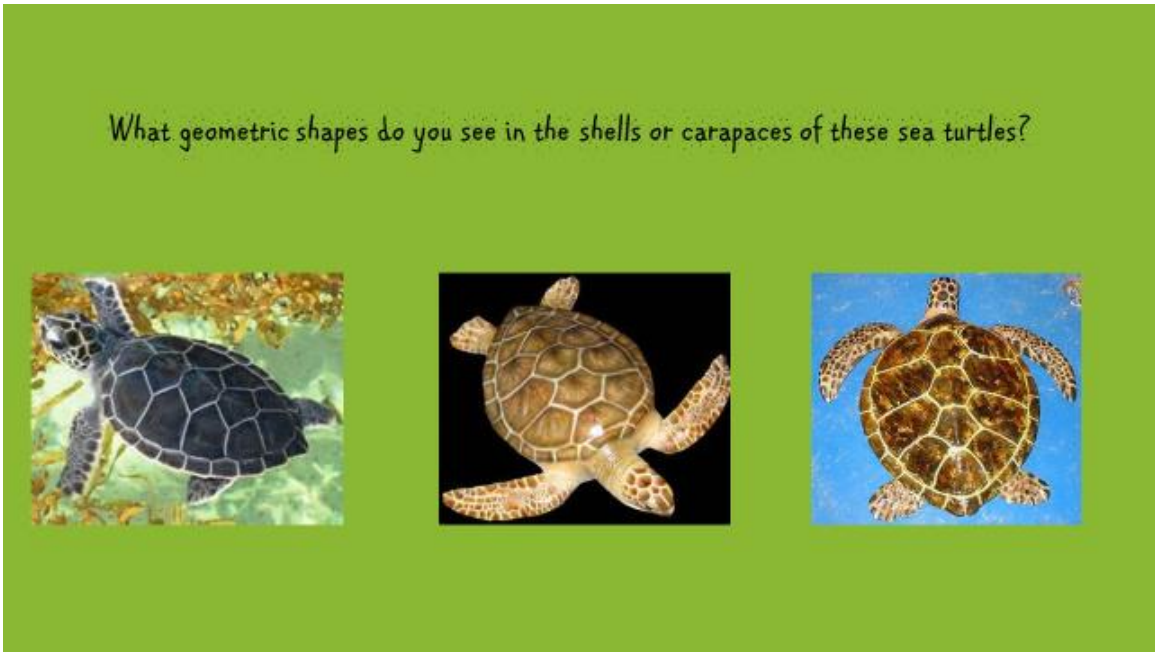

Figure 10. Slide illustrating images of sea turtle shells and their geometric design

Students will look at a variety of images of loggerhead turtles in print or from the internet (see materials list for URL links). Teacher and students together will identify the presence of three geometric shapes in the loggerhead turtles shell/carapace (hexagon, pentagon, and quadrilateral). Students and teacher will count the number of line segments and angles within each shape. Having prior knowledge of types of angles (acute, obtuse, and right), students will identify the types of angles found in the various geometric shapes on the turtle's shell or carapace. Teacher will explain to students that today we will be using our knowledge of geometric shapes to create a ceramic loggerhead turtle and we will be learning about equivalent fractions as we put together our sculpture.

EXPLORE (50 minutes)

Teacher will distribute clay cubes, ceramic tools, and laminated fraction modelling worksheet (see Appendix E). Teacher will ask students to identify the name of the solid figure they have been given. Students will fill in the sentence frame with the word cube and draw a cube in the space provided. Teacher will then instruct students to roll the clay into a ball and ask, “What is this shape called?” Students will fill in the sentence frame on the worksheet. Teacher will then instruct students to roll the sphere into a snake that is as long as, but not longer than, the rectangular box on the worksheet. Students will fill in the sentence frame with the vocabulary one whole. Teacher will then instruct students to use their ceramic tool to cut or divide the snake into two pieces that are the same size. Students will fill in the sentence frames with the vocabulary halves and one half. Teacher will instruct students to write a mathematical sentence 1/2 +1/2 = 2/2 and 2/2 = 1. Teacher will then instruct students to cut or divide one part of the snake into five equal parts. Teacher will draw students’ attention to the concept that each of the five pieces is really equal to ten equal pieces within the entire snake. Students will label each piece as 1/10 and write a corresponding mathematical sentence showing 1/10 +1/10 + 1/10 + 1/10 +1/10 = 5/10. 5/10 = 1/2. 1/2 + 1/2 = 2/2. 2/2 = 1. As an extension teacher can explain that each cut piece can appear to be 1/5, but that 1/5 is 1/5 of 1/2. When working with fractions the word “of” means to multiply the numerators and denominators of the fractions. 1/5 x 1/2 = 1/10. Teacher will instruct students to roll each piece of the snake into spheres. Students will flatten the half piece into a circle and use the modelling tools to etch the geometric shapes of the hexagons, pentagons, and quadrilaterals into the shell/carapace. Students can refer to the scientific diagram of the carapace at:

http://marinebio.org/upload/chelonia-mydas/green-sea-turtle.gif

As students are working, teacher and students will draw attention to whether a particular angle in a shape is acute, right, or obtuse. Teacher will review a line of symmetry with students and instruct them to find as many lines of symmetry within the turtle's shell as they can. Teacher will show students how to shape four of the remaining pieces (1/10) into flippers and attach them to the underside of the shell using etch marks and "slip". Teacher will show students how to shape the final 1/10 into a head and neck and attach it to the shell. Students will crumple a small piece of paper and flip the turtle sculpture onto the "ball" and allow it to dry.

EXPLAIN (30 minutes)

Students will complete a fraction worksheet (Appendix H) using the same rectangular modelling of fractions. Students will complete the sentence frames and write mathematical sentences expressing the relationship between the fractions.

Students will use a lines of symmetry and angels worksheet (Appendix G) with an image of a loggerhead carapace to draw lines of symmetry and identify acute, obtuse, and right angles.

Students can pair share and small group share their responses using the vocabulary from the worksheet to verbally justify their answers. Example: "I divided my rectangle into three equal pieces. I then divided a one-third piece into four equal pieces. This made each smaller piece one-fourth of one-third which makes it one-twelfth."

EXTEND (30 minutes)

Students can look at other types of turtle shells/carapaces and identify geometric shapes as well as lines of symmetry. Some possible resources are located at:

https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcR8zWBaPn8QxlLlYw6LsPxjAAj5CKkjIue6cQ0x8G-wpV3iczYXSA

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQTHpi7JKFU_7jaSZhrZYn7uY7P3WRH5sgz6njOrCyj043zcUgI2w

https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcQfYpsn9FuhQJaHTiID2VEaHKhzXDnaEEyMt7omBLoFDldrhHwOsg

Students can identify symmetry and geometric shapes in works of art or other animals and plants on the internet and from other sources.

EVALUATE (2 – 50 minute sessions)

Students will create an imaginary sculpture from clay. Students will need to divide the clay into parts and correctly identify the fractional name for each piece as it relates to the whole. Students will need to etch a design onto the sculpture that includes acute, obtuse, and right angles and reflects a line of symmetry. Students will write an expository paragraph about their sculpture explaining the fractional proportion of each part and how it relates to the whole. Students will additionally describe the number of acute, obtuse, and right angles reflected in their work. Finally, students will identify the inspirational piece of art and or subject in nature or the environment. See attached rubric (Appendix I).

The format of the P.D. was very well received and will be discussed in more detail further on. The photographs in this slide capture the content of the lesson, as well as the spirited level of engagement the teachers were experiencing.

Figure 11. Photographs from the P.D. on arts integration and STEM

PLCs

In order to meet my fourth objective, I had planned for the first two parts of the P.D. to take about an hour and then have the staff move from the science lab into the computer lab where we could use the computers to look at the NGSS more closely and explore some lesson plans on various NASA websites and build one arts integrated lesson with one element of STEM. This plan did not pan out as there was an emergency meeting for third, fourth, and fifth grade teachers in the computer lab to go over Smarter Balanced Assessment procedures.

This type of last minute change to the schedule and the emphasis on state testing is typical of Castlebay Lane Charter. I was forced to float from room to room where the remaining kindergarten, first, and second grade teachers met to develop lessons. This was not very fruitful as no grade came up with an actual lesson on paper; however, all grades actively looked at the NGSS and discussed ways that they could integrate the arts into STEM. With this in mind, it becomes critical that to meet my final objective of providing my staff with ongoing support and feedback it would be necessary to create a professional learning community (PLC). Teachers were asked through a post P.D. feedback form if they would be interested in a PLC. The purpose of this PLC would be to develop arts integrated STEM curriculum for the entire school. While some teachers expressed the belief that the district should supply all textbooks and materials needed for teaching, Erica Rood commented in the book, *What Really Works in Elementary Education*, published in 2015, that teachers need to stop relying on textbooks as the field of STEM is constantly changing with new and updated research and teachers should look more to the internet for updated content and pedagogy. This echoes my earlier point to teachers that published curriculum is not always aligned to the Common Core and NGSS and is often riddled with flaws.

Discussion of Feedback form Professional Development

The purpose of this graduate project was to educate teachers about the importance of STEM curriculum, while providing them with an anxiety reducing vehicle through which that curriculum could be delivered. The very premise upon which Castlebay Lane's charter was founded demonstrates that arts curriculum is valued for its rigor and is engaging for both students and teachers. Although teachers have been working with

Common Core ELA and math standards for the last two years, the NGSS are new and have not been implemented at our school to date. By presenting professional development in which teachers were actively engaged in a hands-on arts integrated math lesson I hoped to inspire teachers as to the benefits of teaching arts integrated STEM units.

One of my objectives was to insure that teachers were fully engaged in the professional development, just as students should be fully engaged, so that they walked away feeling positive and inspired. Another objective was that my staff felt they had a firm grasp of how an engaging arts integrated lesson in STEM could be developed and executed. Teachers needed to see that the vast number of standards in Common Core ELA and math, the NGSS, and VAPA could be addressed simultaneously, thereby providing more meaningful curriculum in a time conscious and rigor filled manner. The most important objective, and most far-reaching, was to provide my staff with the time and tools to develop their own grade level appropriate arts integrated STEM units. To this end, I wanted to create a professional learning community (PLC).

In order to assess whether these goals had been met I asked my colleagues in attendance to fill out a brief post professional development feedback form. The questionnaire made a series of "I" based statements with a one (disagree strongly) to five (agree strongly) multiple response scale. Of the approximately thirty-three participants, a few of whom were not able to stay for the entire P.D., I received feedback from twenty-seven teachers. I have illustrated the feedback in a more graphic format for simplicity.

	Disagree strongly	Disagree	Neither Agree nor disagree	Agree	Strongly agree
1. I enjoyed participating in this P.D.	0	0	0	7	20
2. I understand the Next Generation Science Standards (NGSS).	1	0	13	9	4
3. I understand how to integrate NGSS, VAPA, and Common Core.	0	0	9	11	7
4. I will develop integrated units for use in my class.	1	0	6	12	8
5. I would be willing to spend my own time developing lessons.	1	1	7	13	5
6. I am interested in forming a Professional Learning Community (PLC) for the purpose of developing integrated lessons.	2	6	10	5	4
7. I am interested in forming a PLC for the purpose of cross grade level articulation.	1	2	16	4	4

Figure 12. Graphic illustration of P.D. feedback based on question

The first statement, “I enjoyed participating in this P.D.” received seven scores of agree and twenty scores of strongly agree. None of the feedback indicated a neutral or negative reaction to the P.D. In this regard, I feel the format of the P.D., which was to have the teachers actively engage in an arts integrated math lesson for the first hour before looking at standards and lesson plans, was a success.

The third statement, “I understand how to integrate NGSS, VAPA, and Common Core,” addressed the second of my goals. Did teachers understand how to develop an arts integrated STEM lesson and overall themed unit of study? One can see in figure 12. that this goal was also mostly met. Close to two thirds of the participants agreed or strongly agreed that they understood how to integrate these standards and the remainder were neutral. No teachers left feeling as though they did not understand how arts and STEM integrated lessons and units could be developed. Unfortunately, the response from the feedback questionnaires indicated that the majority of teachers did not feel they fully understood the NGSS. This was not the main goal of the P.D. and exploration of the NGSS will require further professional development. If additional P.D.s can be developed in a similarly engaging manner, teachers will most likely be happy to attend and leave with a clear understanding.

The last four statements gave insight into how likely the teachers would be to actually spend time developing lessons and what type of support system they would need. The majority of teachers appear to be amenable to the idea of creating their own curriculum and would be willing to spend their own time on the task. However, teachers seem slightly less likely to want to spend their own time. Only a few responses were strongly against this idea and most likely reflect conversations I have had with one particular teacher in the past who firmly believes that the district should provide all curriculum and materials for teacher use. The concept of whose time should be spent developing curriculum comes into focus when the idea of PLCs is raised. The teachers are mostly neutral on the idea of creating PLCs with an even distribution of teachers in favor of and against the idea.

The final statements/questions on the feedback questionnaire were open ended. The last question asked teachers to provide their names if they were interested in actually forming a PLC. Only two teachers provided their names. They are both new to the school; one has been at Castlebay for two years and the other is in her first year at the school and third year of teaching. Although this is not the overwhelming response I was hoping for, it is a start. A small, but very motivated, core of teachers can begin to focus on curriculum development and share the fruits of their labor with additional staff.

The remaining questions asked teachers to list three things they had learned during the P.D. and three things they would still like to know more about. Teachers seem much more willing to circle agree and disagree prompts than to answer open-ended questions. Of the twenty-seven feedback questionnaires, five were completely blank on the back despite a notice to turn the page over. Most of the remaining questionnaires were only partially filled in with brief phrases. However, some responses to the request, “Please list three things you learned today,” are worth noting.

> I realized a lot of topics can be accessed through STEAM.
>
> Integration of subjects makes the lesson more meaningful.
>
> Integrating arts into science and math lessons, clay turtles, super fun.

I learned that I can use clay in many different subjects.

A fun activity to integrate math and art.

Teachers indicated that they would like to learn more about the NGSS, the engineering strand, and how they are going to be assessed. Some additional quotes highlight areas of need.

I need to know more about how to create these awesome lessons!

It would be nice to create several lessons per semester for our grade level.

Ways to get ideas for lessons.

How would you develop this with students with IEPs in mind?

The response to this P.D. both in the feedback questionnaires and verbally as teachers approached me during the following weeks was overwhelmingly positive.

CHAPTER FIVE

Conclusion

The implications for the future are clear. First on the agenda, is to contact the two teachers who have already expressed an interest in forming a PLC and open the PLC up to all other interested teachers. This PLC does not have to be limited to teachers only at Castlebay, but may be more fruitful by approaching interested teachers at other nearby schools. If teachers are averse to meeting in person, an online format like the one used in in the Canadian study conducted by Francis and Jacobsen in 2013 might be an appealing alternative. Several teachers at our school already have Edmodo accounts that they use with their classrooms. This online format allows teachers to join small groups, so the PLC can remain private and limited, as opposed to being part of the larger Edmodo teacher community which is too overwhelming and unfocused.

Once this PLC is firmly established and has the common goal of creating arts integrated units of STEM curriculum, the next step is to develop a series of P.D.s that provide teachers with STEM content and pedagogy to increase their self-efficacy. In the 2013 research conducted by Nadelson et. al., teachers reported improved self-efficacy following completion of a three day summer institute on STEM content and pedagogy. The researchers noted that current and past teacher preparation programs place very little focus on STEM curriculum. Combine this with alternative teacher training programs and one can see a need for STEM professional development. One concern of this study was that participation in the three day institutes was voluntary and that predisposition toward learning more about the STEM field may have influenced the increased self-efficacy results. Based on the undisputed positive feedback from the arts integrated P.D., I am suggesting that teaching STEM content and pedagogy with an arts integration component may have the same effect as voluntary participation.

In addition to arts integration having a positive effect on teacher participation and engagement, the idea of integrating subjects at all has a positive effect on student learning outcomes. Students who studied science concepts in isolation did not show the same gains in content knowledge from pre- to post- test as did students who studied the same science content with an integrated engineering component (Bethke-Wendell & Rogers, 2013). Those students also reported improved attitude toward the learning environment. In a similar fashion students showed significant gains in content knowledge and application of critical thinking skills after participating in an arts integrated program in Chicago' CAPE partnership schools (DeMoss, 2005).

The Los Angeles Unified School District has demonstrated their appreciation for integrated units of study by developing the fifth grade Moon or Mars colonization unit and the newly implemented fourth grade Neighborhood unit with another unit scheduled for third grade next school year. It is imperative that teachers move now to develop arts integrated STEM units of study while we are still in a vacuum between the adoption of new curriculum and outdated curriculum that is not aligned with CCSS and NGSS. While some integrated curriculum exists for STEM subjects, such as *Engineering is Elementary*, there is no such published curriculum for arts and STEM integration. However, an excellent resource that can be used to guide arts integrated curriculum development is *Renaissance in the Classroom: Arts Integration and Meaningful Learning* published in 2001 by Burnaford, Aprill, and Weiss. In addition, the district is still moving in the direction of adopting math curriculum that is isolated.

Teachers must move forward now with arts integrated STEM units of study if we are to meet the critical thinking and problem solving goals of Common Core while capturing and expressing the beauty and awe of nature and the arts which is so engaging.

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Appendix A

Teacher Demographics

1. How many years have you been teaching? ______________________________

2. How many years at this school? ______________________________________

3. What are some outside-of-school obligations and interests you have?

____
____
____

4. Describe the type of program you entered to receive your credential?

____
____
____

5. In what subject is your undergraduate degree? ____________________________

6. Do you hold any post graduate degrees and, if so, in what area?

____
____

7. Are you a National Board Certified teacher? ______________________________

8. Do you identify yourself as an arts or math and science person?

____

Appendix B

Math and Science Anxiety Questionnaire

Please circle the number that reflects your overall feelings regarding each statement.

1=Always 2=Often 3=Sometimes 4=Rarely 5=Never

1. If one of my friends was chosen for answering a question in math class, I felt happy for not being the chosen one.

1 2 3 4 5

2. If one of my friends was chosen for answering a question in science class, I felt happy for not being the chosen one.

1 2 3 4 5

3. I would panic when I started the mathematical part of a standardized achievement test.

1 2 3 4 5

4. I could not ask any questions about what I did not understand in math class.

1 2 3 4 5

5. I did not like doing math homework.

1 2 3 4 5

6. I did not like the equations in science classes.

1 2 3 4 5

7. I did not like doing science homework.

1 2 3 4 5

8. I would panic when I got math homework consisting of many math problems.

1 2 3 4 5

9. When I hold a math textbook to teach I start feeling a stomach ache.

1 2 3 4 5

10. When I hold a science textbook to teach I start feeling a stomach ache.

1 2 3 4 5

11. I could not concentrate on anything before a math exam.

1 2 3 4 5

12. I could not concentrate on anything before a science exam.

1 2 3 4 5

13. I feel confident that I understand how to teach Common Core math concepts.

1 2 3 4 5

14. I am afraid of learning new math methods.

1 2 3 4 5

15. I am afraid of presenting problems to a presenter in a Common Core math workshop.

1 2 3 4 5

16. I avoid helping a child with his work, because I am afraid I cannot explain the solution.

1 2 3 4 5

17. I am afraid of answering math questions on the spot.

1 2 3 4 5

18. I come to the first day of math teaching with hope every year.

1 2 3 4 5

19. I come to the first day of science teaching with hope every year.

1 2 3 4 5

20. I cannot study well for a math lesson because I worry about my performance.

1 2 3 4 5

21. When I open the teacher's manual and look at the pages, I fear I will fail at teaching Common Core math.

1 2 3 4 5

22. I can ask a colleague about a concept, which I do not understand well, in private.

1 2 3 4 5

23. I feel anxious and pessimistic while waiting for the results of student standardized math exams.

1 2 3 4 5

24. I would rather learn a subject presented with numbers or graphics than with words.

1 2 3 4 5

25. When I think about the skills and concepts required for teaching a math class, I feel I cannot meet the standards.

1 2 3 4 5

26. I do not like dealing with numbers.

1 2 3 4 5

27. I feel nervous when one of my colleagues or students notices that I do not understand the solution to a math question.

1 2 3 4 5

28. I have problems listening to math professional development.

1 2 3 4 5

29. The best parts of other P.D.s are the parts dealing with math.

1 2 3 4 5

30. I get nervous when I learn that the next P.D. is on math.

1 2 3 4 5

31. I do not like making calculations in everyday life.

1 2 3 4 5

32. I misunderstand concepts in math courses.

1 2 3 4 5

33. I panic when I cannot remember a required equation for a problem.

1 2 3 4 5

34. I like to look through mathematics books.

1 2 3 4 5

35. Even though I think a salesperson made a mistake about the amount of my charge, I cannot object, since I will not be able to make the calculations while somebody is watching me.

1 2 3 4 5

Appendix C

Attitudes Toward Professional Development

1. In the past two years, approximately how many math Common Core Professional Developments have you attended? ____

2. Approximately how many total hours? ______________________________________

3. What are the key concepts you understand regarding the new Common Core math standards?

____

____

4. Do you feel prepared to develop lesson plans that reflect the new standards?

____

5. How many hours outside of school do you spend on lesson plans with colleagues?

____

6. How many hours do you spend on lesson plans individually? ____________________

7. Do you look forward to developing lesson plans?

____

8. Do you enjoy teaching Common Core math? _________________________________

9. Do you feel there is enough time in the day to implement curriculum as it has been presented to you? ____

10. Do you understand how to develop lesson plans that integrate multiple subjects into one lesson? ____

11. Do you develop lesson plans that integrate multiple subject areas into one lesson?

____

12. If so, please give a brief example.

____

____

____

13. How familiar are you with the Next Generation Science Standards?

Very Familiar   Somewhat Familiar   Barely Familiar   Not at all Familiar

14. Do you enjoy teaching Common Core? ____________________________________

15. Based on level of engagement, do you feel your students enjoy Common Core?

____

Appendix D

STEM into STEAM Feedback Questionnaire

Please circle the response that best fits your opinion:

Disagree Strongly	Disagre	Neither Agree nor Disagree	Agree	Agree Strongly
1	2	3	4	5

1. I enjoyed participating in this P.D.

1 2 3 4 5

2. I understand the Next Generation Science Standards (NGSS)

1 2 3 4 5

3. I understand how to integrate NGSS, VAPA, and Common Core

1 2 3 4 5

4. I will develop integrated units for use in my class.

1 2 3 4 5

5. I would be willing to spend my own time developing lessons.

1 2 3 4 5

6. I am interested in forming a Professional Learning Community (PLC) for the purpose of developing integrated lessons.

1 2 3 4 5

7. I am interested in forming a PLC for the purpose of cross grade level articulation.

1 2 3 4 5

Please turn over

8. Please list three things you learned today.

____

____

____

____

9. Please list three things you would like to know more about.

____

____

____

____

10. Would you be willing to develop an integrated lesson in the next four weeks and have feedback?

Yes No

If so, please write your name ____

Appendix E

Loggerhead Turtle Fraction Worksheet

cube   sphere   cylinder   snake   sculpture   one-whole   halves   one-half   five   one-tenth   one-fifth

My clay __________________ starts with a ____________________of clay. It looks like this

I rolled my _____________________into a ______________________ with my hands.

I rolled my _______________into a ___________________which is called a ____________ in ceramic art.

I have _______________________ cylinder/snake of clay.

__________ __________

I divided my cylinder/snake into two equal parts called___________________________. Each part is called __________________. Write a mathematical sentence showing the relationship between the two parts of the snake and the whole snake ____.

__________ _____ _____ _____ _____ _____

I divided one half of my snake into ___________ equal pieces. Each piece represents _____________ of the whole snake. Write a mathematical sentence showing the relationship between the parts of the snake.

____

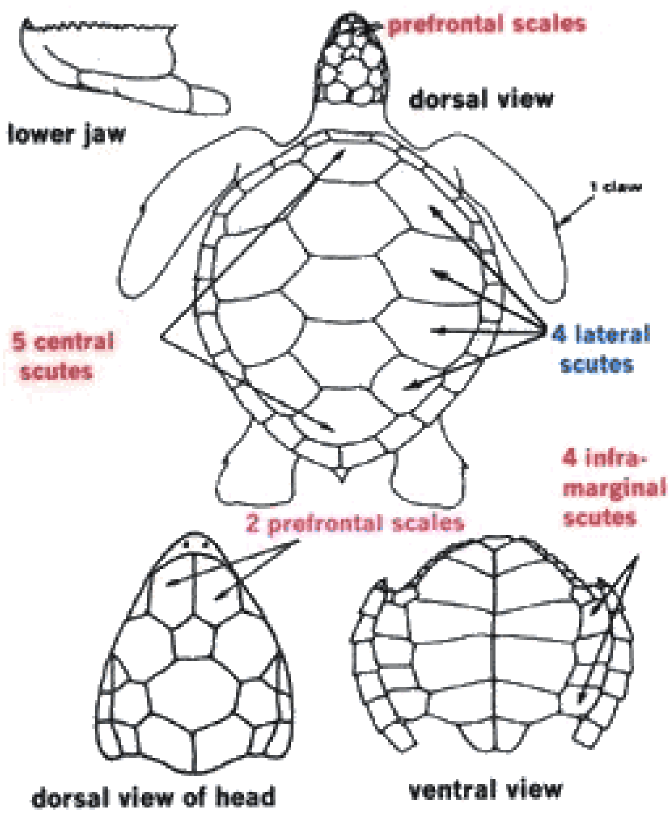
Extension:

Each piece is __________ of __________. Write a mathematical sentence expressing the relationship of the pieces.

____

Appendix F

Loggerhead Turtle Shell/Carapace Diagram

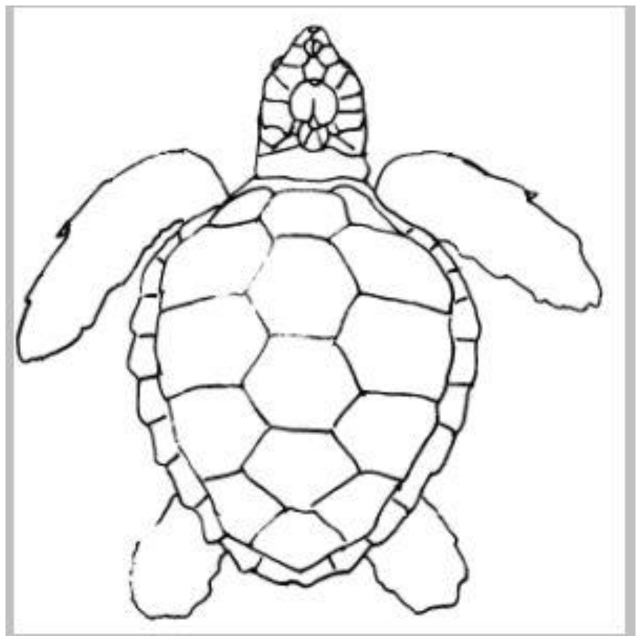


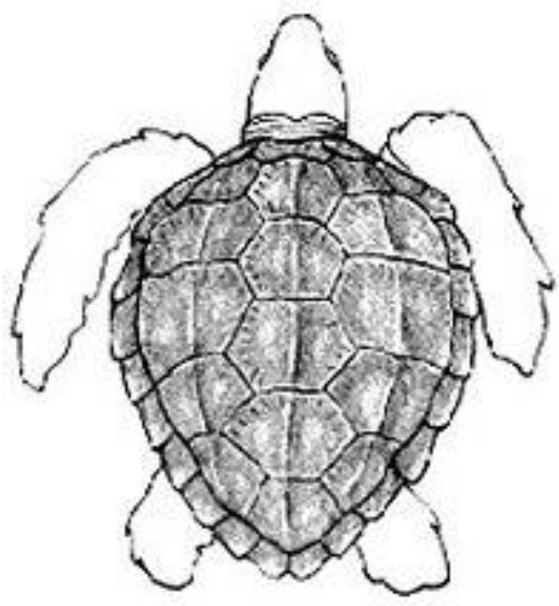
- Smooth oval shell
- Brown/yellow greenish color
- 4 pairs of lateral scutes
- 5 central scutes
- 2 prefrontal scales
- Serrated lower jaw

Appendix G

Loggerhead Turtle Worksheet: Identifying Lines of Symmetry and Acute, Obtuse, and Right Angles

Label acute angles with the letter A, label obtuse angles with the letter O, and label right angles with the letter R. Draw lines of symmetry with a red pencil.





Appendix H

Fraction Worksheet Using Modelling

Divide this rectangle into two equal parts and label each part as a fraction.

__________ __________

Write two mathematical sentences expressing the relationship between the two parts.

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Divide one-half of this rectangle into four equal parts and label each part as a fraction.

__________ _____ _____ _____ _____

Write two mathematical sentences expressing the relationship between the parts.

____

Divide this rectangle into three equal parts and label each part as a fraction.

__________ __________ __________

Write two mathematical sentences expressing the relationship between the parts.

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Divide one part (one-third) of the three parts into three equal parts and label the new parts as a fraction**. Be careful to think of what the part would be if you did the same in each third.**

__________ __________ _____ _____ _____

Write mathematical sentences expressing the relationship between the parts.

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Appendix I

Grading Rubric for Loggerhead Turtle Fraction/Geometry Lesson

Standards Addressed	CCSS Fractions 4.NF.A.1	CCSS Geometry 4.G.A.1 4.G.A.3	Arts 5.2 2.2 2.3
4	Student correctly identifies each part of the creature and labels it as a fraction. Student uses more complex fractions such as 1/5, 1/6, and/or higher fractions. All fractions add up correctly to one whole.	Student creates a pattern on the creature that incorporates all three types of angles (acute, obtuse, and right). The design has multiple lines of symmetry.	Student's work reflects the inspirational piece in design elements and correctly applies ceramic production skills. Work is of greater detail and skill.
3	Student correctly identifies each part of the creature and labels it as a fraction. Fractions add up to one whole. Fractions used are 1/2, 1/3, and/or 1/4.	Student creates a pattern on the creature that incorporates all three types of angles (acute, obtuse, and right). The design has a line of symmetry.	Student's work reflects the inspirational piece in design elements and correctly applies ceramic production skills.
2	Student has only two parts to the creature or student mislabels some parts. Student does not correctly add fractions to equal one whole.	Student creates a pattern on the creature that incorporates only two of three types of angles (acute, obtuse, and right). The design has a line of symmetry.	Student's production skills are poor and make identification of design difficult to observe. Sculpture does not completely hold together. The work does not clearly reflect the inspiration piece.
1	Student mislabels all parts of the creature using incorrect fractions. The fractions do not add up to one whole.	Student creates a pattern on the creature that incorporates only two of three types of angles (acute, obtuse, and right). The design has NO line of symmetry.	Student's work does not hold together and has no relationship to the inspiration piece.