Second Grade Students Learn about Civil Engineers and Erosion

Andrea Earline Anderson
University of Northern Iowa
and
Jessica A. Meier
Waverly-Shell Rock Community School District

Abstract

The integration of art into curricula focused on teaching science is a new perspective in education designed to reach a broader range of students. The current study examined the process of second-grade students participating in science and art activities through qualitative content analysis. The subjects of science and art were not taught to the students separately, rather, students engaged in both subjects simultaneously, in an integrated manner. Participants were 23 second-grade students (11 female and 12 male; age range 7 to 8 years) who were learning about erosion through sketching and creative construction and the work of civil engineers through role-play and exploration of problems they solve. Sources of information for the study included student-reported symbolism for engineering badges, classroom discussions, students' responses during testing of sand hills, teacher observations, and student writings. Major themes in the process of the students were: connections to prior knowledge of erosion and engineers along with symbols connected to engineers; observing erosion and shapes of the land; integration of art bringing motivation; social learning and teamwork; problem-solving solutions to erosion; making connections between the classroom testing and the real world; and the desire to continue exploring erosion. The lessons emphasized learning *through* and *with* the arts, making the lessons engaging and motivating students to continue learning on their own.

Key Words

Arts integration, elementary students, erosion, civil engineers

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Introduction

Arts Integration is a research-based approach which enhances student academic gain and success. Brewer (2002) defined integrated art curriculum as a blending of art instruction with another subject area, such as science. Robinson (2013) supported the increase of STEAM (Science Technology Engineering Arts and Mathematics) in schools, suggesting the utilization of arts integration is a strategy for planning and teaching Common Core standards which has shown benefit through the creation of deeper learning experiences for students. Interdisciplinary art curriculum, incorporating Common Core standards, provides educators an opportunity to combine more than two areas of learning through various arts disciplines allowing for a broader range of creativity (Brewer, 2002). Therefore, one benefit of arts integration is creativity across all curriculum subjects can be used as a way to engage students of various intellectual abilities.

The No Child Left Behind Act of 2001 placed emphasis on schools utilizing standardized measuring and testing as a means to assess their students' progress. With time constraints and financial burdens facing administrators and educators, areas such as the arts and even science, became neglected (Cawelti, 2006). Yet, education is currently experiencing a paradigm shift as government legislation of No Child Left Behind becomes the Every Student Succeeds Act, transferring authority from the federal government to states and local schools (Fránquiz, 2016). The resulting paradigm shift encourages educators and administrators to plan and implement curriculum focused on meeting the education needs of the *whole* child as opposed to an isolated subject from which to measure progress from standardized testing; therefore, increased research is needed to explain the benefits of arts integration on the learning process of children as a whole.

As schools continue to phase out of No child Left Behind policies, administrators and educators are in need of new ways to measure student success and motivation. Brewer (2002) examined an increased interest from political and administrative parties in which emphasis is placed on integrated curriculum in public schools. As the trend to increase the utilization of integrated curriculum continues to grow, there is a need for qualitative researchers to study arts integrated activities with real students, in real classrooms as a means to showcase benefits to the process of student learning. The present qualitative study adds to the growing body of knowledge in studying the learning process through arts integration.

This paper presents an overview of literature pertaining to arts integration and the learning process for children. Data from this study were collected through lessons that support the Common Core Curriculum and Next Generation Science Standards with emphasis on engineering concepts and arts integrated activities. Students' learning process related to concepts of erosion and the work of civil engineers was studied through qualitative content analysis, as described in the methodology section. Emergent themes and results are discussed, followed by concluding remarks.

Literature Review

Historical Perspective on Arts Integration

Historically, researchers and educators have recognized a need for an increased presence of arts integration into formal academic settings. Gullatt (2008) traced the origins as far back as the late 1800s, in which Horace Mann advocated for the inclusion of visual arts in schools. In the early twentieth century, Dewey identified and supported the idea that there was a "positive correlation between cognition and instruction in the arts; this linkage had a strong effect on numerous curriculum decisions in many places at that time" (Gullatt, 2008, p. 154). Continuing through the middle of the twentieth century, arts integration became more prevalent in schools; but, as standalone subject for its own sake, not with the mindset of utilizing arts to improvement achievement and motivation in other subjects. As the study of curriculum in public schools progressed, Eisner (1974) called for the evaluation of arts programs, which produced measurable evidence suggesting arts education positively affects broader success in learning, beyond the intrinsic values of the arts themselves. By the 1990's, researchers investigating arts integration began developing new programs and practices grounded in the idea that the arts are cognitive. Distinguishing the cognitive role of art, Efland (1990) clarifies the arts as participatory, emphasizing feeling and imagination. As research in arts cognition increased, educators continued to increase integrating arts into other subject areas to aid in academic success. The measurable results researchers were tracking in addition to the anecdotal evidence teachers were witnessing in their classrooms supported the paradigm shift in formal education to recognize the role of arts benefits beyond the arts disciplines themselves.

The Power of the Arts

At present, researchers in the areas of arts integration and education are helping explain the arts' potential as a powerful tool to enhance teaching and learning. Burton, Horowitz, and Abeles (1999) conducted a study to determine if cognitive skills developed through arts learning can be applied beneficially in other subject domains. Specifically, cooperative/social learning, development of expression, and imagination/creation were examined in individual students with specific attention paid to transfer learning between the students. Results from this study found transfer learning to be one of many benefits resulting from arts learning; however, *how* transfer learning occurs specifically resulting from arts learning has yet to be determined.

Information gained from this study in relation to social learning suggested utilizing a variety of methods to allow for student development in multiple levels of thinking in which art cognition can be successful (Burton et al., 1999). Gullatt (2008) suggested the personal and emotional content of arts as the key ingredients from which the arts become cognitively powerful. In general researchers agree one of the benefits of arts integration is a deeper, cognitive learning process; although the question many researchers are still trying to answer is *how* the cognitive process occurs through the incorporation of the arts.

Efland (2002) supported the need for a societal shift in which the arts are recognized as a crucial part of learning, as it is through art cognition in which students engage in learning processes made from personal connections. Furthermore, it is through personal connections, knowledge gained from the community in which one lives, in which children can understand the role they play in society and how art can aid them in understanding these connections (Efland, 2002).

The expression and construction of art is one way in which children develop positive self-identity with their community. Arts integration in education builds upon cognitive processes for students as they perceive and understand the world around them (Nevanen, Juvonen, & Ruismaki, 2014). Children learn as they connect their thoughts to the emotional experiences in understanding themselves and those around them.

Arts as Part of School Learning

A balance is needed in which schools provide their students with opportunities to explore unique styles for learning, through arts integration. Currently, schools still operating under the policies of No Child Left Behind, emphasis to prove academic achievements of students is tracked and measured through testing and grades. The popular trend has been to focus on a standardized form of education. Student standardized test scores are used to obtain desperately needed funding for schools. As schools face financial hardships, the arts have fallen to the wayside due to a general lack of understanding of their importance to learning, specifically in regards to *how* teachers and administrators can track their success. Researcher Sahlberg (2006) warned that with the emphasis on academic subjects and standardized testing; arts have become overshadowed with neglect to skills development, the risk is to a weakening in encouraging and fostering innovation and creativity. The field of art education in terms of a paradigm shift is an example of how political and administrative policies, rather than student learning considerations, become a catalyst for change in elementary school classrooms. Further research examining the role of art education and *how* the learning process occurs in children is needed to guide educational policies with student learning considerations in mind.

Scholars in elementary school education have argued that schools should emphasize children's well-being alongside learning, the utilization of arts integration (with particular attention paid to the development of spatial skills through engineering) may be the bridge needed to link together social emotional well-being and academic success. Yet, as evidenced from Webb, Lubinski, and Benbow (2007) in which their study discovered that today's K-12 curricula do not include enough opportunities to develop the spatial ability of students. Brophy and Evangelou (2007) observed children engaged in art cognition and engineering designs displayed creative/constructive behaviors which were driven by the use of their imagination in line with an engineering frame of mind. As elementary schools offer curriculum based arts integration through engineering design and process, they are providing their students with learning opportunities through positive experiences. The interactive process of learning requires thinking and processing information to achieve commitment and motivation to continue (Hautamaki et al., 2002).

Learning skills are developed through interactions between a students' ability in connection with the lessons and information provided by their teachers. Given the opportunity to work collaboratively offers students a place to practice their communication skills while developing and honing leadership and teamwork skills (Mann, Mann, Strutz, Duncan, & Yoon, 2011). Students engaged in the learning process feel confident in their academic skills and abilities, resulting in an increase to their motivation. This positive feeling of capability encourages these students to practice and learn new tasks in which the student is an active participant in the process constructing their information and learning new skills (Anderson & Peck, 2007).

The Arts Provide Needed Motivation

The educational research literature in regards to student motivation has been strongly influenced by the constructivist learning theory, which defined learning as an "active process in which learners are active sense makers who seek to build coherent and organized knowledge" (Mayer, 2004, p. 14). Students look for personal meaning when tasked with learning something new, when personal meaning is established there is a deeper feeling of motivation to continue learning. Furthermore, when tasked with a new subject, one of particular difficulty, students rely on concentration and persistence to master the problem at hand. Arts integration offers a multi-dimensional solution to tackling difficult problems as students are encouraged to examine the problem from multiple perspectives. Gardner's (1983) multiple intelligences theory provided research-based evidence for the claim that human intelligence is multi-faceted, thus students should be provided multiple perspectives for learning. Research results from Eisner (1998) encourage educators and researchers to highlight the importance of art integration based on the need to respect art as a subject on its own of great importance; "We do the arts no service when we try to make their case by touting their contributions to other fields. When such contributions become priorities, the arts become handmaidens to ends that are not distinctly artistic and in the process undermine the value of art's unique contribution to the education of the young" (Eisner, 1998, p. 15). Parsons (2004) suggests curriculum which includes art integration address social learning and active inquiry.

Where areas, arts integration in education results in a deeper learning process, the measurement of standardized testing is rather shallow. The problem with relying heavily on standardized testing is that many skills students possess are not measured. Typically, standardized tests measure mathematical and linguistic skills. The skills obtained through arts integration are not easily measured on a standardized test as they are not able to measure a student's happiness, enjoyment, or their love of learning. DeMoss and Morris (2002) encourage educators and researchers to develop a variety of ways to represent the multiple learning processes of student growth in art integrated curriculum. As examined in research from Pintrich (2003), the current view of motivational theories are concerned with the energization and direction of behavior, however, further research should focus on how students' arts-integrated learning provides both cognitively and affectively different experiences. Students engaged in making and experiencing art develop skills that will carry over into all aspects of their lives; such as: visual and spatial skills, interest in new experiences, and self-resilience to overcome mistakes. (Winner & Hetland, 2008) Researchers Catterall (2002) and Brouillette (2010) found that a student's ability to concentrate, interact with peers, and problem solve were all positively related to quality arts integration programs in schools.

Qualitative studies and anecdotal evidence, suggest a more long-lasting benefit to students is a positive change in attitude towards school itself as general research on arts integration has shown students engaged in a learning process which emphasize arts education and activity see an increase in self-knowledge and self-assurance which aids in the development of a balanced personality (Russell & Zembylas, 2007). Working alongside one another, art cognition and engineering design encourages students to question the process and examine the activity from multiple perspectives. The questioning process, as discussed by Mann et al. (2011) is collaborative and cooperative, leading to deeper understanding of the problem and possible solutions. Further engagement in the questioning process engages students in both critical thinking and good communication skills. Students engaged in collaboration through arts integration are provided opportunities to cultivate peer relationships through cooperation and interaction. Arts integration in the classroom utilizes activities aimed toward the exploration of meaningful and significant tasks, providing students with opportunities to develop persistence and self-reliance (Nevanen, et. al., 2014).

The available scholarship on arts integration has shown many benefits to allowing students the opportunity to explore and learn through this multi-dimensional learning approach. Marshall (2005) has argued the use of art integration promotes learning and creativity. Yet, there is a great need to provide further evidence based studies promoting the increase of arts education in regards to the process of *how* students learn; specifically, the guiding forces in the process of *how* students learn. There is a need for qualitative research examining arts integration and the learning process as Robinson (2013) identifies this need as few studies have examined the effects of arts integration on student success. Furthermore, Pintrich (2003) makes a plea for more research that examines the different levels of analysis with specific interest paid to different social interactions may interact to produce motivated behavior.

Engineering Design and Process through the Arts

Children are natural engineers through play; building blocks, sand castles, and pillow forts are just a few examples of ways in which children design and build. Furthermore, children are naturally inquisitive and often look for understanding how things work. These natural skills found in many children to inquire and design provide educators with opportunities to set up engineering activities allowing children to learn naturally through their own curiosity. Educators have the opportunity to build on these curiosities through engineering explorations in elementary school (Mann et al., 2011). As students are involved in project-based learning they can work together to engage in the design process of their activities. The significance between engineering activities and personalized learning in students is examined by Mann et al. (2011) with regard to 'Engineering in K-12 Education'; "the engineering component puts emphasis on the process and design of solutions instead of the solutions themselves. This approach allows students to explore…in a more personalized context, while helping them to develop the critical thinking skills that can be applied to all facets of their work and academic lives. Engineering is the method that students utilize for discovery, exploration, and problem-solving." (Engineering in K-12 Education, 2009, p. 53) The availability of engineering activities in the K-6 curriculum provides opportunities to develop concepts, skills, and habits of the mind that are valuable in all disciplines (Mann et al., 2011). Benefits of engineering habits of the mind include systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations (Katehi, Pearson, & Feder, 2009).

Methods

Arts and Science Standards

Two of the National Science Standards were applied to this lesson. The topic addressed in this lesson was Earth's Changes. The first standard utilized in this lesson was 2-ESS2-1: 'Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.' Students tested engineering solutions to their self-constructed sand towers. The second standard applied was 2-PS1-2: 'Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.' Students answered teacher-guided worksheets and open-ended questions regarding what engineering solution they tested, as well as what worked about their solution, and what did not work about their solution. Students were provided opportunities to both write their answers as well as sketch their answers. Both of these science standards met the engineering requirement.

Additionally, three of the National Core Arts Standards (National Coalition for Core Arts Standards, 2014) were applied to this lesson. The first standard utilized was Media Arts, Anchor Standard 3, 2nd (MA:Cr3.1.2) a. "Construct and assemble content for unified media arts productions, identifying and applying basic principles, such as positioning and attention." The students were allowed to independently construct landscapes through positioning and gluing arts materials. The second standard applied was Media Arts, Anchor Standard 5, 2nd (MA:Pr5.1.2) b. 'Demonstrate use of experimentation skills, such as playful practice, and trial and error, within and through media arts productions.' Students first had the opportunity to view a slideshow informing them of the variety of roles a civil highway engineer assumes. Second, students were informed they would role-play as a civil highway engineer and were given blank badges to decorate with emblems of their choosing. By way of connecting the art construction of the badges to the engineering constructing and testing of their sand hills and erosion solutions, students wore their badges as dramatic play to fill the role of being a "real" engineer. Eisner (1997) stresses the importance of teachers to use art in conjunction with social studies and dramatics. Students role-played as civil highway engineers in groups of 2-3, taking turns with their constructed landscapes to test engineering solutions for their sand towers. Within the groups students took turns measuring and applying water to their sand tower, as well as, sketching and observing changes to their sand tower after water was applied. The third standard applied was Visual Arts, Standard Anchor 1, 2nd VA:Cr1.1.2a ‘Brainstorm collaboratively multiple approaches to an art or design problem.’ Students brainstormed as a whole class multiple engineering solutions to addressing erosion. Students discussed which engineering solutions they tested, as well as what they perceived to work well within their solution, and what they perceived to not work well within their solution.

Research Question and Study Overview

The aim of this study is to engage in a deeper examination on the role of arts integration in education, resulting in recommendations and decisions regarding STEAM curriculum based more on evidence. The following research question was addressed through this study: “What is the process of 2nd grade students learning about the work of highway engineers and how do arts play a part in that learning?”

This study analyzes the process of early elementary students learning what civil highway engineers do through a qualitative investigation. In this project, second graders learn about the careers of civil highway engineers who work to prevent hillsides near roads from caving into the roads or having erosion problems. The second graders test a hill of sand (molded into shape in a paper cup) for erosion by dropping water drops on it with eyedroppers. Then they test three other civil highway engineer solutions to erosion: 1) sand hill covered with gauze to simulate geo-fabric on a hillside, 2) sand hill partly covered with aquarium gravel to simulate a boulder-covered hillside, and 3) a collar made of the 1-inch rim of a paper cup to simulate a retaining wall. The arts are incorporated into the lessons through design of a civil engineering badge, making of an aerial view map by assembling and gluing images, and sketching the sand hills and engineering solutions.

Participants

The study was conducted with 23 second-grade students (11 female and 12 male; age range 7 to 8 years) at a mostly White middle-class public school in the Midwestern United States. Approval to conduct the study was obtained from the university and the elementary school principal. All students and parents provided written consent for participation. Participant classrooms were selected based on their teacher’s involvement in a workshop aimed at incorporating arts integration into the curriculum.

Research Design

The investigation had a qualitative approach with students participating in science curriculum which integrated artistic constructive exercises. A qualitative approach was chosen as it allows for data collection, data analysis and theory to stand in reciprocal relationships with each other and follows an iterative process of constant comparison within and amongst data cases, theory and researcher field notes and memos (Charmaz, 2011; Gordon-Finlayson, 2010). It can be said children and qualitative research have two things in common: in the moment they can both be unpredictable. Sinkovics & Alfoldi, (2012) acknowledge that the actual course of real-life research amongst qualitative researchers rarely goes as planned. Qualitative research is gathered and influenced through interactions and on-the-spot decisions (Van Maanen 1998). The authors were not neutral parties in this study, rather an interactive approach was employed as qualitative data were collected via student interviews and observations addressing science and arts integrated lessons. Qualitative data included teacher instructions and interactions with students, student’s written responses, and student’s final product. Additionally, interviews and observations were analyzed for major themes.

Lesson Procedures

The study was completed over the course of two days consisting of three parts that the instructor judged as presenting arts integration into science lessons. The research design of this study was built upon the importance of interaction amongst teacher and student. In the classroom setting, learning is not mutually exclusive to the student. Art cognition and discovery, when taught through social interactions, can provide educators and students with opportunities for intellectual growth (Brewer, 2002). Furthermore, students engaged in teacher led activities in alignment with engineering habits of the mind (Katehi et al., 2009) with specific attention paid to guiding and informing students' engineering process and design.

During the course of two days, students experienced interactive activities with incorporating arts into the science curriculum presented to them, with additional interaction from the researcher examining their motivation and interest in the subject matter. Students utilized the arts in science through two ways: 1) dramatic play- creating their own civil engineer badge and being presented with an engineer problem (how to slow/prevent erosion of their sand hill) in need of solving by them, the engineer, thus fulfilling standards 2-ESS2-1 & and Media Arts, Anchor Standard 3, 2nd (MA:Cr3.1.2) and, 2) the method of solving and discussing the engineer problem presented to them through the use of trial and error of pre-planned solutions provided to them by the instructor, thus fulfilling standards 2-PS1-2 & Media Arts, Anchor Standard 5, 2nd (MA:Pr5.1.2). Students presumed personal meaning through the incorporation of dramatic play as they engaged in interactive roles as civil highway engineers. During the activities, qualitative data was gathered through tracking students' facial expressions, physical behaviors, the products and explanations made during lessons, and their interactions with peers and instructor. Additional data were collected through participant-researcher interactions in the form of verbal statements. Finally, researcher collected field notes as well as student responses to worksheets which were later analyzed and coded for emergent themes.

The two lessons the students participated in were organized based on the 5E's learning cycle format as presented in Table 1. The 5E's Learning Cycle focuses on engagement, exploration, explanation, expansion, and evaluation.

Students in the current study were provided with identical packets in which to create their own civil engineer badge and respond to questions about the activity. The identical packets provided to students included pre-selected questions for the students to answer regarding their activities, as well as opportunities to sketch and draw what they were thinking and observing. Due to the young age of the students, and their limited exposure to standard science curriculum, pre-selected questions were utilized by way of familiarizing and guiding the students in alignment with the roles of engineers. As stated in the literature review, engineers focus on observation, analysis, and problem-solving; providing students with pre-selected questions aided in familiarizing the students with the inquisitive design of engineers.

A slideshow was shown to the class as a whole in which the role of civil highway engineers was discussed in its relation to erosion. Students volunteered verbal responses to erosion examples in and around their city. The personal community in which the students live was discussed in regards to observing erosion organically. Furthermore, students provided examples of community helpers they were familiar with in regards to their roles as problem-solvers and engineers. Students were instructed to create a badge unique that was personal to them as they would be playing the role of a civil highway engineer and would be presented with a problem to solve during the next lesson. The act of students creating a badge unique to them and identifying themselves in the role of engineers connects to research from Berghoff (2005) regarding students' ability to think abductively; connecting mental models of ourselves with our learning experiences. Berghoff (2005) further argues abductive thinking occurs when students engage in art integration. Students each decorated their own badge and answered the following questions: (a) What color is your badge? (b) How did you decide to decorate your badge? Due to the young age of the students, and varying knowledge of engineers and erosion, pre-selected questions were chosen for the students to answer. Students were encouraged by the researcher to construct personal meaning between their current knowledge of erosion and civil highway engineers with connection to the decoration of their badges. Allowing the students to construct personal meaning provided them with connections to the erosion lesson as they would next assume the role of pretending to be an engineer in need of solving a real problem.

At the start of the second part of the lesson the badges were returned to the students, each student was also provided with an identical kit containing paper roads, trees/bushes, and hills in which to construct and test their sand tower upon. Working independently, students used glue sticks to construct their own landscapes on which to build their sand towers. As a whole class, students observed a demonstration from the teacher on how to build their sand tower, affix their engineering solution to it, and drip/count their water to simulate a landslide. During the second part of the activity, students were chosen at random to receive one of three engineer solutions to slow/stop the erosion of their sand tower; 1) cheesecloth, 2) retaining wall, or 3) rocks. Students were provided with sand, tubs, magnifying glasses, water and droppers, and glue sticks with which to construct their activity. Working in groups of 2-3 students; each student took turns testing their engineering solution, dripping water onto their sand hill, counting the number of water drops used, and observing the changes water caused to their sand hill in terms of erosion. Students utilized magnifying glasses to observe the changes water brought to their sand hills and what role their engineering solution played in these changes. Students sketched their observations of their sand hill.

The activity concluded with a whole class discussion of the three engineering solutions tested and what role these solutions played in erosion. A slideshow was shown to the whole class highlighting the solution of each group as well as an accompanying photo of their sand hill. Each group spoke to the class as a whole about what engineering solution they tested, what worked or did not work about their solution, and what solution they believed to be the most effective for addressing erosion.

Table 1. *Lesson Procedures in the 5E's Learning Cycle Format for the Two Lessons*

Learning Cycle Part	Main Purpose	Lesson Activity
Engagement	Focus student attention on the topic	Role-play being a civil engineer by creating a landscape map with roads on it from given clip art images and colored paper.
Exploration	Activate student prior knowledge, discover what students know Cause self-questioning	Students are asked what civil engineers could do to keep the hillsides from tumbling down onto the roads and from eroding.
Explanation	Provide examples and explanations	Students view a slideshow of what civil engineers do such as building roads, bridges, tunnels, sewer systems, etc. with accompanying definitions alongside the pictures.
Expansion	Practice new concepts in a different way or domain	Students create their own engineer shields. Students write about why they choose their shield. One half of the worksheet will have a shield or circular-shaped emblem with the words "Civil Highway Engineer" on it. The student will decide the symbols to be added to the emblem and color it.
Evaluation	Determine what students learned	Students journal about their shields and why they chose their specific symbols. Students will write briefly about how their symbol relates to what a civil highway engineer does.
Engagement	Focus student attention on the topic	Students are told they will have an opportunity to experiment on their own land to see erosion with their own eyes.
Exploration	Activate student prior knowledge, discover what students know Cause self-questioning	Students are told their lesson will focus on 'erosion' and how it changes our land. Students are asked to focus on "*What does water do to our sand hills as we get them wet?*" Students brainstorm as a whole class what they think might happen as their hillsides get wet; "*What do you predict might happen?*" This discussion will allow the children to share what they may already know about earth's changes. This will also allow the children to mentally prepare themselves for the activity.
Explanation	Provide examples and explanations	Students work together to build a sand hill to simulate a hillside atop their roadway sheets. Students sketch their newly constructed sand towers. Students drip water onto their hillsides to witness erosion.
Expansion	Practice new concepts in a different way or domain	Students are given materials corresponding with the landslide solution; cheesecloth cone, aquarium rocks, or paper cone retaining wall. Students construct and test their preventative methods.
Evaluation	Determine what students learned	As a whole class students view a slideshow with photos of their experiments. Students engage in discussions about the pluses and minuses of their constructions.

Data Collection and Instrumentation

Data were collected through qualitative approaches. Data collection included teacher and student interactions, observations, analysis of student product and explanation made during the lessons, and student responses to teacher questions and worksheets. During the lessons field notes were taken in regards to observations of student interactions with other students, the teacher, as well as with the researcher. Additionally, the researcher took pictures of the students during their activities which were later examined to analyze the students'' interest in the activities through their participation and facial expressions.

Students' creative processes resulting from the lessons were analyzed by facial expressions, verbal statements from the students expressing positive feelings toward the lesson as well as unusual ideas put forth, as well as students' overall participation in the activities and the products they constructed. A packet containing questions for the students to answer was provided to the students to gauge their interest in the activities and knowledge gained through participation.

Students wrote their responses to the following questions: (c) Draw what your sand tower looks like. (d) Write down how many drops of water you dripped on your sand tower. (e) What does water do to our sand towers when they get wet? (f) What engineering solution are you going to test? (g) Draw your sand tower with you engineering solution on it. (h) Did your engineering solution help your tower? (i) What did you like about your solution? (j) Was there anything wrong with your solution? (k) What solution would you use to stop a landslide?

Table 2. *Data Sources for Qualitative Analysis in Chronological Order*

Lesson Activity Data Sources
Teacher read book on erosion and students provided community examples of erosion
Student ideas brainstormed during or after slide show of landslides
Student comments during slide show of what civil engineers do.
Making and explaining the symbolic badge for a civil engineer in a journal
Predicting what will happen when sand hills are dribbled with water
Student observations and drawings of eroded sand hills
Generating ideas of how to stop erosion in real life and on the sand hills
Comments made while and after testing of erosion solutions
Group presentation of their tested solution and their explanations of why it did or did not work and suggestions for future testing

Results and Discussion

Themes

Through the use of qualitative data analysis, twelve general themes emerged regarding the thought processes of the study participants. Data was gathered from the examination of field notes, pictures, students' verbal statements & facial expression, as well as completed student products. Table 3 lists the general themes in order of occurrence, with several of the themes sharing a ranking number as they were so closely intertwined. Figure 1 shows a cycle in which the student's learning process occurred. First, students engaged in discussions in which their base knowledge of erosion tapped in to by way of gaining their attention and eliciting a personal connection to the activity. Second, as students utilized their base knowledge they gained further awareness of erosion and roles of civil highway engineers, thus, expanding their personal connection to the tasks at hand. As students engaged in dramatic play as civil highway engineers, observed erosion along with testing solutions, they were able to connect the activity to arts cognition through their drawings and sketches. Additionally, as the activity progressed it relied on collaboration and teamwork which resulted in social-learning. As the students experienced success (their solution worked) and failures (their solution did not work) heighten motivation and enjoyment was observed as the students wished to continue the activity outside of class in their real-world settings. Thus, the cycle came full circle as the activity settled into the students' minds as knowledge gained and they looked forward to stopping or preventing erosion.

Table 3. *General Themes that Emerged from the Data Analysis*

Theme	Order
Prior knowledge connection to erosion or erosion solutions	1
Connect erosion to engineers who stop or prevent it.	2
Learning about Civil Engineers and Developing an identity of being a civil engineer by finding symbols that they relate to and that fit with civil engineers	3
Observing the erosion in action	4
Shape of the sand tower discussed	4
What erosion looks like	4
Connecting the activity to art	5
Motivation , enjoyment, fun, fantasy	5
Social Learning and teamwork	5
Problem-solving about the erosion solutions	6
Connecting solution to real world	7
Desire to continue exploring erosion	8

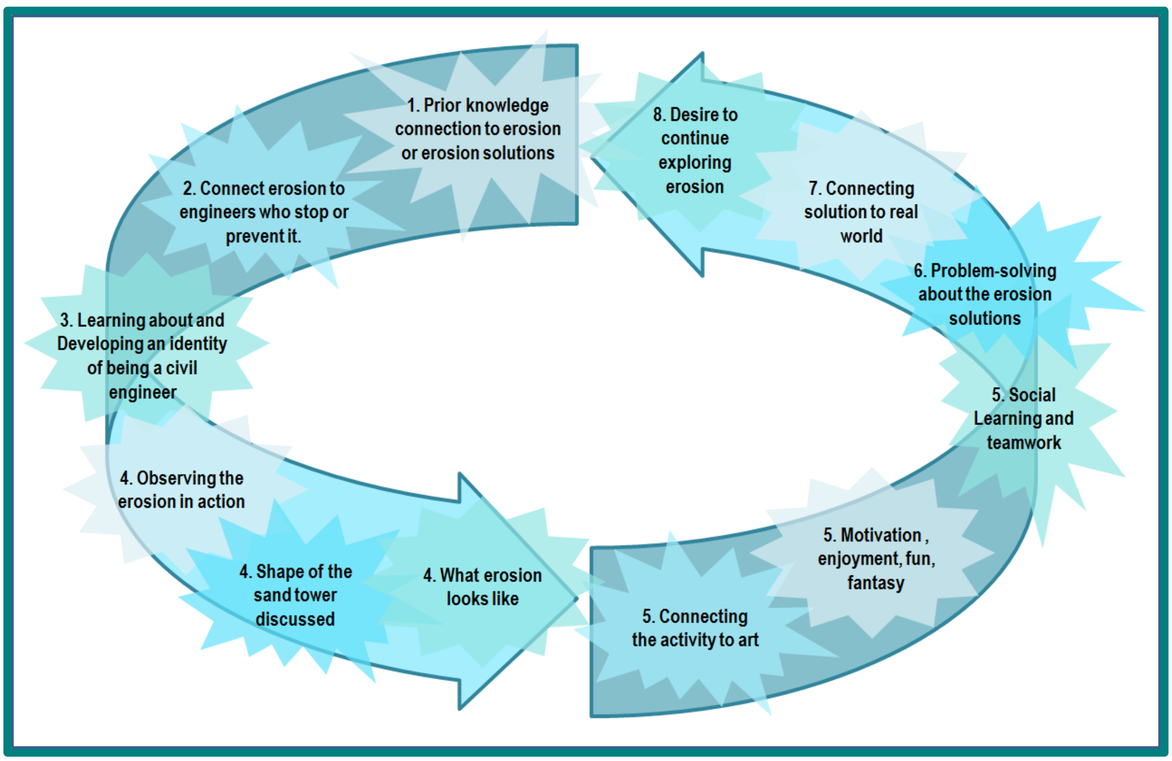

Figure 1. Qualitative diagram of emergent themes related to process of students exploring erosion and the role of civil engineers through the arts.

Discussion of Themes

Prior knowledge connection to erosion or erosion solutions. Students varied in their level of prior knowledge regarding erosion and erosion solutions. General examples of a process that causes erosion included “dripping rain can make erosion," and “flooding can cause fast erosion.” Other students provided more specific examples of erosion, such as “in Colorado there are nets to catch falling rocks - example of where have seen erosion,” and “The Green Bridge is closed because of flooding and erosion - it's dangerous.” The students examples of general knowledge and specific knowledge regarding erosion support their thought processes as they connect the new material they were being presenting with, to their previously acquired knowledge of science. This is in line with previous research in constructivist learning theory in which one of the expected benefits is the depth of learning and understanding of new material when students connect to their prior knowledge (Baeten, Dochy, & Struyven, 2013).

Connect erosion to engineers who stop or prevent it. This theme was reliant on teacher direction in which students were guided on connecting their prior knowledge to the new material they were being presented with. Students were shown a slideshow of photos of Civil Engineers accompanied with examples of erosion problems the engineers encounter as well as solutions they may utilize. Additionally, the teacher gave verbal examples to the students regarding erosion problems and solutions.

Learning about civil engineers and developing an identity of being a civil engineer by finding symbols that they relate to and that fit with civil engineers. Students were shown photos of civil engineer badges with a variety of emblems. Students engaged in a class discussion exploring the meanings behind the different badge emblems. Following the class discussion, students worked in small groups to design and decorate their own badges. Students immediately began connecting the role of highway civil engineers to that of community helpers as this is a theme of second grade social studies. An example being, “I colored my badge red and blue like police. Police help people and people need roads so the engineers are like police because they’re both helpers. I want to be a helper too!” Providing students with examples of careers and professions can help students look toward a hopeful future for them as they envision themselves in those roles. Researchers Douglas & Strobel (2015) support identifying with future careers as students’ levels of hope contribute to their academic success, creating foundations in which students can look forward to the opportunities that education affords.

Observing the erosion in action. Students engaged in an activity which showcased erosion in action as their sand hills became wet without the help of an erosion solution in place to keep their hill upright. Students then participated in the testing of erosion solutions as shown in Figure 5. As students worked together to test their problems and solutions their critical thinking process was observed as they actively conceptualized, evaluated information gathered from their observations and experience, resulting in action (Scriven, 1987). Students observed erosion and discussed what they saw, “my net (solution) was easy to put on my tower and it worked really well! The water made a chunk of sand fall off my hill but the net caught it,” additionally, “I need to smoosh more rocks in there (in reference to piling them around his sand hill) because these aren't heavy enough and the water is flooding them away.” This connects to the students’ abilities to observe a problem in action and then think of a corresponding solution.

Shape of the sand hill discussed. As the activities progressed, students noticed the shape of the sand tower or hill and made basic science observations of shape, "our solution was good because it kept our sand shaped like the cup we used to build it,” elaborating further, "our sand tower stayed big and tall even after we dripped a lot of water on it." This connects to the students developing spatial skills of determining the effects of dripping water in different positions. As the students observed the changes in their sand hills they began to rely more on their engineering skills to continue their investigation into how erosion occurs and what their role is to stop it. As pictured in figure 2. students conduct investigations to determine information, to test the effects of different actions, to discover and interpret patterns, and to explore how to do something (Harlan, 2001). Additionally, Downs and DeSouza (2006) expound the relationship between engineering and art as spatial thinking skills are demonstrated as students notice shapes and their changes. Spatial skills (spatial visualization, mental rotation, perspective taking, etc) by way of problem solving are of particular importance to success in STEM fields. Researchers Stieff and Uttal (2015) emphasized that given the nature of STEM problem solving, a student's achievement in STEM is reliant on how capable they are at solving problems that involve reasoning about spatial information. Students that engage in STEAM activities which require spatial skills are provided with more opportunities for students to practice and strengthen their problem solving abilities.

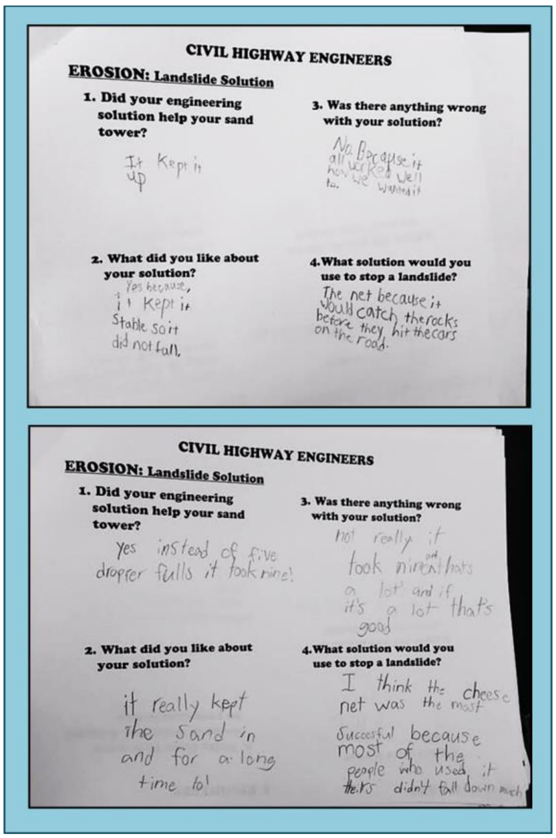

Figure 2. *Example student responses to erosion solutions.*

What erosion looks like. Students utilized their observation skills during the activity as they examined the physical aspects and actions of their sand hills. One student explained "my water drops made my sand hill get weaker, and then too much water made my sand hill fall over." and another student commented "my net covered my sand tower and my sand tower didn't fall down after I put a lot of water on it!" Students also engaged in cause and effect observation as they witnessed the changes erosion and their engineering solutions had on their hills, "we took turns dripping a lot of water and the water made a big chunk of sand fall off, but the net caught it so it didn't fall all the way down."

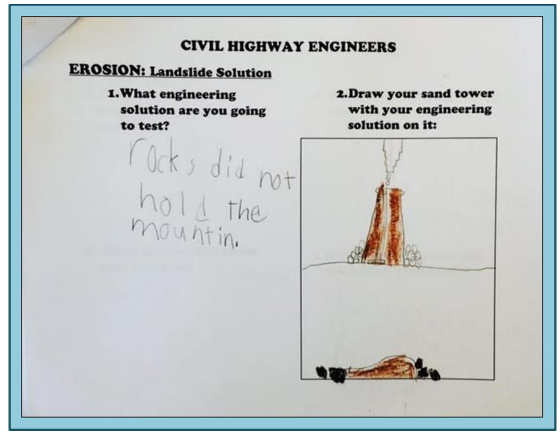

Figure 3. *Example student responses and sketches to observing erosion.*

Connecting the activity to art. The badge making activity was one way in which students could bridge their prior knowledge to the new knowledge being presented in the lessons. Given the young age of the students, their knowledge of civil highway engineers varied and was somewhat limited, although they were familiar with the notion of community helpers and could identify certain colors (blue for police, orange for construction) as a way in which to strengthen their personal connection to the subject. It was through the teacher's guidance of discussing engineers and their roles that students could build personal connections As research from Lord (1998) states "new knowledge results when information encountered cognitively interacts with what the learner already knows" (Lord, 1998, p. 581). Allowing students to choose their favorite colors for participating in this activity heightened the students' involvement and enjoyment. Students chose crayon colors based on their personal preferences as a way of identifying with creating their own civil engineer badge, "I made mine really colorful because all the emblems looked different so I used different colors." This theme is supported by previous research from Mishra (2012) in which the importance of the relationship between creativity and technology is of great significance. Researchers and educators in the field of STEAM have argued that teaching and learning needs to explore the relationship between technology and creativity, particularly in educational contexts. The connection of this art activity to engineering is supported by Mann et al. (2011) as Engineers visualize their imaginative ideas mentally, on paper, or on computer displays; furthermore, engineering activities often culminate with the creation of new three-dimensional artifacts.

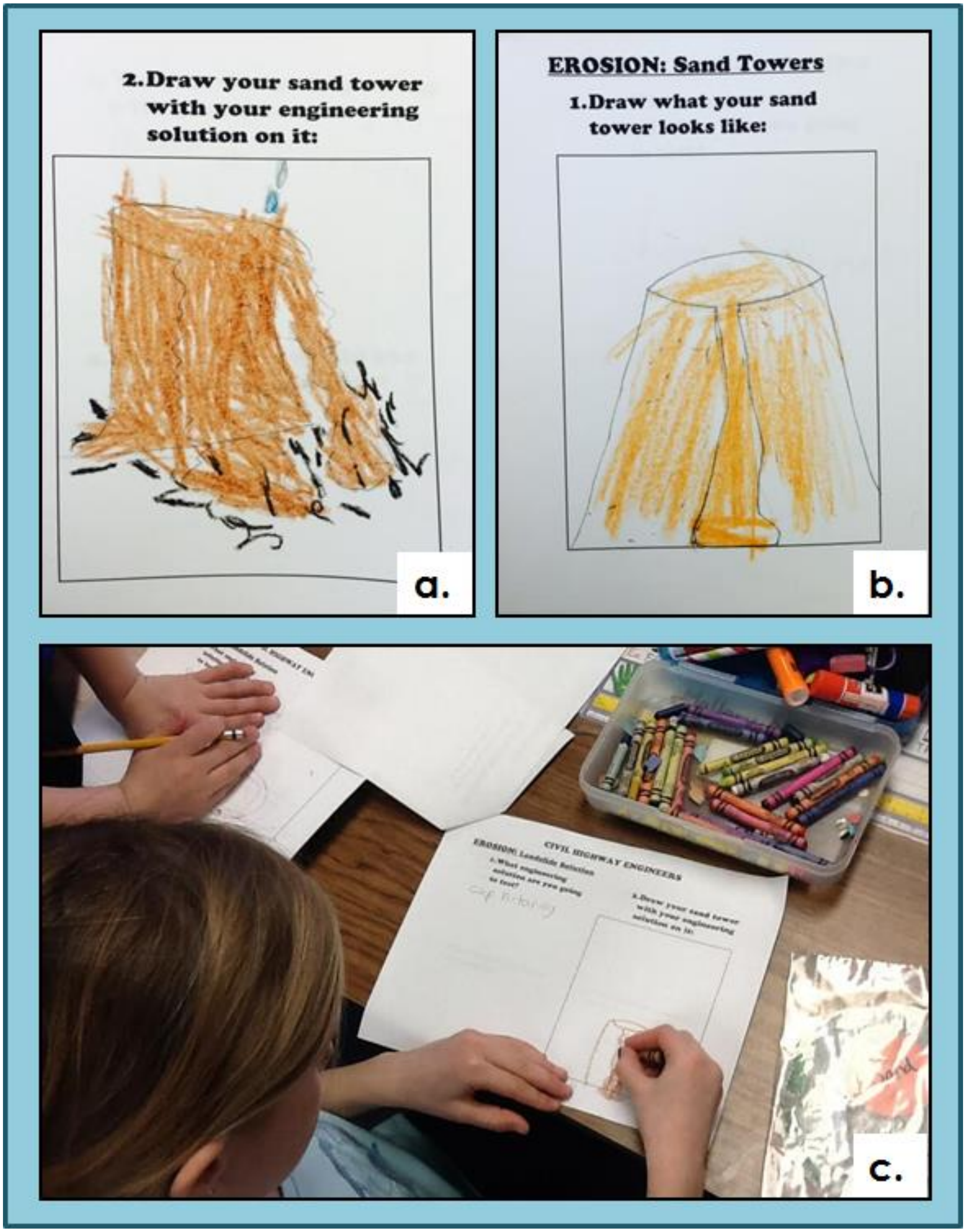

Figure 4. Students' drawings of sand hill erosion observations.

Motivation, enjoyment, fun, fantasy and desire to continue exploring erosion. Students displayed high levels of enjoyment and motivation through positive body language (smiling, cheering, clapping) and verbal communication, “I'm going to make this at home but I'm going to use my Legos to make a HUGE wall!" another student responded "me too! But I'm going to stick Band-Aids all over my tower to hold it together!" Students became very creative in their desire to enjoy this activity outside of classroom. Arts integration encouraged the students’ motivation and enjoyment of the activity in connection to their creative thinking. As creative thinking provides students with varying perspectives from which to encourage different motivational styles, the different types of extrinsic motivation to intrinsic motivation highlights idea that there are multiple creative pathways and there is a need for more research on how students pursue these different pathways and how they are socialized to internalize the different styles (Pintrich, 2003). The need for arts integration in scientific based activities is a way in which creativity can be expanded and explored through enjoyment. Research from Mishra (2012) emphasizes the importance of creativity in our classrooms as creativity in science is crucial, and creative thinking skills between varying disciplines certainly have similarities. In addition to displaying happiness and excitement toward participating in the erosion lesson in class, students communicated creative alternatives to continue the activity outside of class. This theme is in alignment with constructivist learning theory in which the artistic activities aided in the enhancement of students’ motivation for learning.

Social Learning and teamwork. Working in groups allowed students to discuss ideas through social learning. The cognitive theorist Vygotsky (1962) stated that learning from experience is the process through which human development occurs. As students are learning together and working in small groups, the human development of their thought process is expanded. During the course of activities in this study, students participated in whole class discussions guided by their teacher, as well as small group discussions in which students talked to their tablemates. Students enjoyed learning with one another as expressed by their enjoyment and enthusiasm, one example being, "Cool! I'm going to move my hill over like yours so my roads can twist all the way down!" This type of social learning through design activities provided opportunities for students to engage in collaboration and teamwork. In alignment with Mann et al. (2011) learning to work collectively allows students to flex their communication skills as they bounce ideas off one another to with the common goal of developing a more creative design. Additionally, students improve their communication skills as they learn to compromise, listen, critique, and work together (Mann et al., 2011). Students were able to rely on one another throughout the learning process by observing the ways in which differing students approached their activities from different perspectives.

Connecting solution to real world. Research on the topic of authentic learning focuses on the application of knowledge gained in the classroom to the application of knowledge in the real world. As discussed by Rule (2006) authentic tasks help learners transfer their school learning to real world settings through the connection of prior knowledge, skills and attitudes, and coordination of individual skills. Students made a lot of connections between what happened to their sand hill model and what happens in the real world. For example, when referencing how engineers construct real retaining walls, students remarked, “we need to try to glue the rocks together to build a wall like the real ones do.” This connection to real world engineers highlights the student’s observation skills as well as their motivation to take part in the activity successfully. Key aspects of engineering are the generation of solutions and development of real-world products while working independently and as part of a team (Mann et al., 2011). Furthermore, another student communicated their desire to apply their solution to their community, “my solution worked well and kept all the sand in the shape of my hill. I liked my solution because it kept it stable so it did not fall. I would use the net in real life so it could catch falling rocks before they hit cars driving.” This statement emphasizes the student’s desire to apply their scientific knowledge of erosion and safety to the world in which they live. This theme emphasizes that students need to be able to ask good questions; gather, analyze, and interpret data; and communicate their findings (Mann et al., 2011).

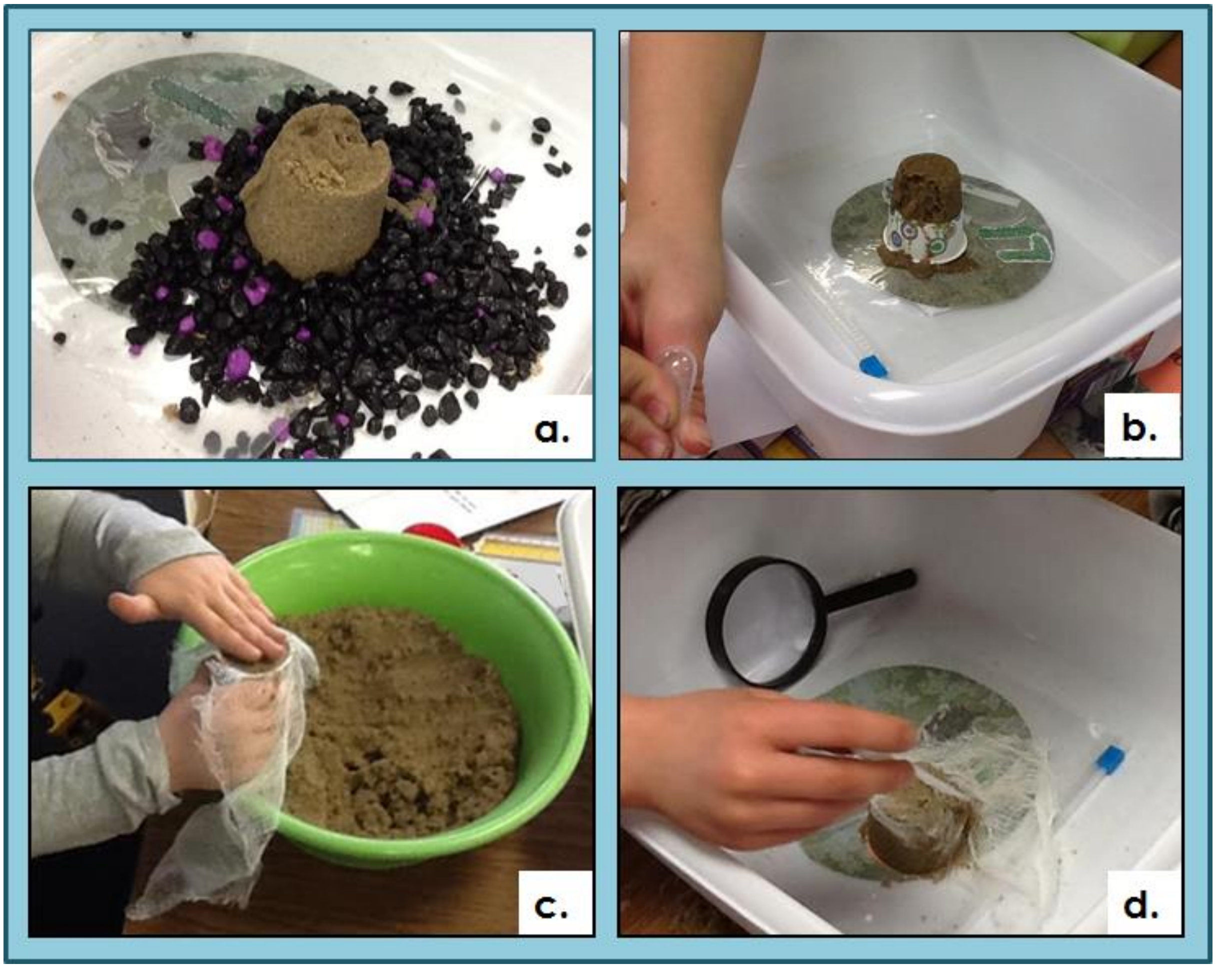

Figure 5. Examples of students testing different engineering solutions to erosion on the sand hills. Image a shows a student-built rock wall. Image b shows a student preparing to test the paper cup retaining wall. Image c shows a student packing sand into the cheesecloth structure. Image d shows a student removing the supporting cheesecloth from the sand tower.

Conclusion

Summary of Findings

Students learned about erosion and the roles of civil engineers through art integration. Students constructed their own civil engineer badges, choosing their own colors and illustrations, as a way of identifying with the activity. Students wore their badges as they roleplayed an activity in which they identified a problem (sand and water erosion) and tested potential solutions. Students constructed paper landscapes, built sand hills upon them, and observed what happened to their hills when they dripped water on to their hills. Students sketched their observations and answered open-ended questions about the erosion process. After observing the problem of erosion, students applied a solution (rocks, nets, or walls) to their sand hills and re-tested dripping water to observe the new changes. Students sketched their sand hills with their applied solutions and answered open-ended questions about the activity. Lastly, students engaged in a whole-class discussion summarizing their engineering experiences. The engagement of a whole-class discussion was important to the engineering process as it provided students an opportunity to reflect upon what worked well during their project as well as areas hat needed improvement.

Implications for Classroom Practice

The learning process for children engaged in science and art integration highlights the need for teachers to engage children from a multi-perspective approach. Art cognition emphasizes multiple perspectives, as does engineering, incorporating the two in a classroom lesson recognizes that there are multiple solutions to most problems. The engineering design process is a useful, lifelong skill and requires students to utilize and improve a variety of types of thinking (Mann et al. 2011).

A multi-perspective approach teaching science through quantitative (instrumental) and qualitative (integrated) activities with the use of art provides opportunities for students to connect their classroom experience with real-world application. Curriculum which focuses on science from a purely quantitative perspective is doing students a disservice. Brewer (2002) stresses of the inclusion of art integration as the ends to a means, without acknowledging arts integration as a subject of solo importance, can take away from the integrity of qualitative curriculum. Furthermore, continued research from Brewer (2002) warns that artistic qualitative curriculum produced under the guise of only promoting another subject tends to be more surface learning, missing the deeper benefits of arts integration on a student's motivation to continue exploring. When integrated art is used in this fashion, student learning in the arts does not fulfill requirements set forth by national or state standards for visual arts. An overemphasis on integration used instrumentally may in fact subvert on those standards unless art is studied as a distinct discipline (Brewer, 2002).

Teachers can implement and support science and art integration in classroom practice in the following ways: build course curriculum to address individual student interests, strengths, experiences, and needs, as well as, provide students with interactive, social-learning focused on scientific concepts or ideas through artistic construction. Teachers should involve students in the process of assessing understanding through active dialogue and communication. Finally, teachers can support social-learning and motivation by cultivating a classroom community emphasizing cooperation, shared responsibilities, and enjoyment.

Suggestions for Future Research

Addressing various ways, in which children learn through the use of creative activities in a typically quantitative subject, provides opportunities for teachers and researches to guide students into the area of math and science for a motivational and enjoyable experience. This study, in addition to research from Douglas & Strobel (2015) have identified the great need for measures of success which include students' ability to connect current effort with future success in life or STEM careers. There is a need for research that focuses on students' hope related to STEM education. Future research in the area of science and art integration would benefit from quantitative studies focusing on the social-learning process and enjoyment of children.

As art integration becomes more integral in common core curriculum, more students will have an opportunity to excel in math, science, and technology. STEAM learning as a collaborative process between qualitative researchers and educators, can familiarize children with the stimulating world of creativity.

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