Arts Integration into Elementary Science: Force and Motion and Natural Disasters

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Abstract
This study explored the effect of arts integration into science during an instructional unit on force and motion and one addressing natural weather disasters. Seventy-eight elementary students in four classrooms (grade 5, grade 4, and two at grade 3) participated in the study. This study assessed content retention, student-made products (rollercoasters and hurricane shelters), and student attitudes. All students in each classroom experienced the two units of instruction, one unit in the experimental condition of arts integration and one unit in the control condition without arts integration. Both conditions involved students in constructing models of given materials. Each unit consisted of three weeks of instruction with the last week being a final project scored for science content and creativity. This final rollercoaster model or hurricane shelter model supported engineering standard 3-5-ETS1-2. Grade 4 and grade 5 classes showed significant posttest gains and distal posttest gains regarding content scores in favor of the experimental condition with a large effect size. The mean overall product scores favored the experimental condition with a very large effect size. The results indicated that arts integration produced greater creativity, collaboration, and more positive overall perceptions of learning.

Key Words
Arts integration, force and motion, natural disasters, elementary students, research study.

Introduction

STEM (science, technology, engineering, and math) is a curricular concept that has garnered much attention in the last decade. Integration of two or more of these important subjects is an innovative approach meant to engage students and prepare them to think critically so they can become the innovators, educators, researchers, and leaders solving the challenges facing our nation (Department of Education, 2017). Recently, an argument has been made for the arts to mesh with STEM, creating STEAM (Haroutounian, 2017). Integrating arts into STEM allows logical scientific and more imaginative artistic processes to work together to enhance learning. A benefit of arts-integration is the positive effect it has on long-term learning (Hardiman, Rinne, & Yarmolinskaya, 2014). However, more research is needed to better establish the connection between STEAM education and sustained student achievement.

Previous research in the realm of arts integration has shown positive benefits in utilizing the arts both as a means of learning and as a means of sharing learned knowledge (Gershon & Ben-Horin, 2014). Some research has even shown a correlation between arts integration and non-academic behaviors such as self-esteem, life satisfaction, and meaning and purpose (Martin, Mansour, Anderson, Gibson, Liem, & Sudmalis, 2013). Benefits in the area of language arts have been researched in an arts intensive program, showing that participating students scored an average of 10% higher on English language arts standardized tests than students who were not in the program (Peppler, Powell, Thompson, & Catterall 2014). Numerous articles have been published about arts integration describing many correlated benefits; however, little research focused on improvement of learning retention has been published and even less concerning learning retention in regards to STEAM. Arts integration, while not necessarily improving immediate recall of information, does appear to affect longer retention of learning as demonstrated by delayed (distal) testing scores (Hardiman, Rinne, & Yarmolinskaya, 2014).

The focus of the current study was to document the effects of art integration into STEM education. The counterbalanced, pretest-posttest-distal posttest repeated measures study examined retention of science content with and without art integration as well as content learning improvement, creative features present in a final project related to each condition, student enjoyment of lessons and student perceptions of their own learning. Participants included students in four classrooms at the third (two classrooms), fourth, and fifth grade levels. The distal posttest was used to measure the retention of the unit-related science content after a period of time. The main hypothesis of the study was that integration of art into STEM content areas would increase content knowledge as well as the retention of that knowledge over time.

Literature Review

This review of pertinent literature begins with a discussion of the importance of STEM education, then moves to the benefits of arts integration into the curriculum, especially the STEM curriculum, producing STEAM education. Finally, literature related to student engagement is addressed as arts integration has been found to increase student engagement and this aspect was measured during the study.

STEM Education

Science, technology, engineering, and mathematics (STEM) education research has recently become more common because of the projected percentage of job increases that require skills in the STEM field. Much of this increase is due to the growth in new technologies, as well as the recent push towards being a global competitor in these areas. Youth and young adults are being required to think deeply and critically to become the innovators, educators, researchers and leaders for these coming challenges (Department of Education, 2017). With this push to increase STEM education in lower elementary grades, some teachers, accustomed to direct instruction, are finding themselves unprepared to teach students in a meaningful way. Goodnough (2014) discusses the lack of teacher preparation and professional development in the area of STEM education as a possible explanation for students' lack of STEM readiness. However, even with this initiative supporting STEM education, students are still not graduating with the skills required of these new jobs (Land, 2013). Arts integration with STEM combines logical, systematic, convergent science thinking with divergent, intuitive, imaginative arts thinking proving a new perspective on the content (Land, 2013). Arts integration is one answer proposed to help increase the number of students that would be ready to take on new and innovative careers after graduation.

Arts Integration

There has been much debate as to the importance, or benefit, of the arts in relation to learning. One proposed idea is that there are two main, and contrasting, lines of thinking when it comes to these benefits which include: 1) engagement with the arts enhances cognitive ability to learn content and 2) engagement with the arts cultivates dispositions (such as perseverance) that are beneficial to other aspects of life (Rinne, Gregory, Yarmolinskaya, and Hardiman, 2011). An example supporting the first benefit is that training in the arts improves attention, which in turn improves cognition (Posner and Patoine, 2009). The brain has a system of neural pathways devoted to attention. Practice that involves focus and repeatedly activates attention networks improves intelligence. Most arts like playing an instrument, painting a mural, or learning lines for a play require frequent practice and strong engagement to do them optimally. These arts undertakings activate and exercise the same attention networks used in academic thinking (Posner and Patoine, 2009).

There is a correlation between involvement in the arts and academic success. A study that followed 25,000 students for ten years, including their middle school and high school education, examined the outcomes of involvement in the arts across all disciplines, finding that as time in arts-influenced coursework increased, so did students' success levels, including students from low-income families and those whose parents had low levels of education (Catterall, Chapleau, & Iwanaga, 1999). This same study reported that students who consistently studied instrumental music over these years evidenced higher levels of mathematics performance. Finally, students who were consistently involved in drama through plays, clubs, or lessons showed gains in reading proficiency, improvement in self-concept and motivation, and higher levels of empathy and tolerance for others (Catterall et al., 1999).

A review of empirical studies published between 2000 and 2005 (Russell & Zembylas, 2007), found that a major benefit of arts-integration was that student grades improved or maintained achievement levels and an important long-term benefit was a positive change in attitude toward school. These authors warn that the integrity of the disciplines into which the arts are integrated must not be compromised or shallowly addressed when including arts integration. Connected to this is the need for teacher preparation to model arts integration well and to demonstrate how to fit an integrated curriculum into a school day that often has discrete time allotments for each subject (Russell & Zembylas, 2007). These issues were addressed by the current study by ensuring that science standards were being met and by teachers planning the lessons to fit the school day schedules. Another literature review of studies into arts integration concluded, "Further investigation of transfer, the impact of arts on cognitive development and the interaction of cognitive and affective processes in the arts is warranted" (Burnaford, Brown, and Doherty, 2007, p. 75). Few experimental studies that have researched these ideas were located; therefore, research into this area is warranted.

One recent study that did explore these connections was conducted by Hardiman, Rinne, and Yarmolinskaya (2014). In a counterbalanced design of fifth-grade students learning about astronomy and ecology during two instructional units, the achievement of students learning the same concepts through the arts was compared to students learning the same concepts without arts integration. The study showed no initial differences in student learning on a posttest, but when a distal posttest was given, students who learned the concepts in conjunction with the arts showed a greater retention of learning. Similar to Hardiman et al.'s study, the current study has two science units, force and motion and natural disasters, and involves several classes of students in a counterbalanced manner. In addition to a pretest-posttest comparison, a distal posttest was be used to determine long-term retention of content. Because few true experimental studies have been found to explore the connection between the arts, STEM, and learning, the current study was designed to examine a connection between arts integration, STEM, and student attitudes, creativity, and engagement.

Student Engagement

According to Abbott (2016), student engagement is the "degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught..." Research has shown that engagement is critical for student success in learning. Students who are engaged learn more, retain more, and enjoy learning activities more than students who are not so involved (Akey 2006, p 3). Student engagement is manifested in behaviors, such as effort, attention, and problem-solving; engagement is also manifested in attitudes such as passion, creativity, and perceived success.

Classrooms that foster student engagement are classrooms focusing on students' sense of belonging, setting clear and consistent expectations, and engaging students in meaningful and relevant curriculum. Students who have a strong support system of teachers, friends, and family are more likely to have positive academic attitudes. These students enjoy attending school, learn more, and report they are more engaged in academic work. Research also shows that students who are asked to conduct experiments, build models, participate in debates and role-playing, and complete projects are more likely to be engaged in their learning (Akey 2006, p 5-6).

Previous studies have shown a correlation between student engagement and singular content areas, such as reading, math, or science. The current study evaluated student engagement during STEM activities. Student attitudes towards success, collaboration, enjoyment and creativity will also be evaluated.

Method

Lessons in this study focused on two science topics: force and motion, and natural disasters. This study used pretests, post-tests, and distal tests to determine student achievement and retention of learning.

Research Questions

The primary purpose of this study was to show the possible effects of arts-integration, specifically when combined with the STEM subject of science, on student retention of content, student achievement, and student attitudes. This research is important because very few studies have explored the relationship between STEM and STEAM addressing retention of learning.

This study was designed to address the following question. Does arts integration improve content learning in the two science units of force and motion and natural disasters? Sub-questions included: (a) do students produce constructions with more science content ideas or more creative features under one of the conditions; (b) do students prefer arts-integrated units over typical science units; (c) do students perceive they learned more content, were more creative, or more collaborative during one of the conditions; and (d) do students retain more science content under the arts-integrated condition? These research questions were chosen because we wanted to address other factors that influenced student achievement through STEAM.

Research Design

This study took place in classrooms taught by three elementary teachers, as shown in Table 1. All teachers taught a science unit about force and motion for thirty minutes daily the first three weeks and then switched to a unit on natural disasters with daily 30-minute lessons for the second three weeks. Each class of students experienced the control condition for one unit and the experimental unit with arts integration for the other unit. The pretest and identical posttest and distal posttest addressed content taught in the lessons for each topic.

Table 1. *Study Design*

	Teacher 1	Teacher 2	Teacher 3	
Grade Level	5th Grade Class	4th Grade Class	3rd Grade Class 1	3rd Grade Class 2
Pretests	Force and Motion and Disasters Units	Force and Motion and Disasters Units	Force and Motion and Disasters Units	Force and Motion and Disasters Units
Weeks 1-3	Force and Motion Control Condition	Force and Motion Experimental Condition	Force and Motion Control Condition	Force and Motion Experimental Condition
Posttest	Posttest for first unit studied: Force and motion			
Weeks 4-6	Natural Disasters Experimental Condition	Natural Disasters Control Condition	Natural Disasters Experimental Condition	Natural Disasters Control Condition
Week 6	Posttest for second unit studied: Natural disasters Distal Posttest for first unit studied: Force and motion			
Week 9	Distal Posttest for second unit studied: Natural disasters			

Next Generation Science Standards

The lessons in this research project addressed science and engineering standards of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). These standards have just been adopted by the state of Iowa (the state in which the study occurred) for public school children. These standards include engineering components that have not been in previous sets of standards and which pose problems for teachers trying to implement them because of unfamiliarity. Therefore, publication of lessons that successfully implement the engineering standards with documented evidence of their efficacy for students are greatly needed as guiding examples for teachers. America's future depends upon education of students for the STEM fields with a workforce of individuals who can think creatively to produce new innovations and solutions to the many problems of the world.

The current study addresses the NGSS engineering standard 3-5-ETS1-2: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. All students had two opportunities to implement work that supports this standard: making a rollercoaster model that displayed principles of force and motion and creating a model of a hurricane shelter that could withstand water and wind testing. These models were made under both conditions, but art components were implemented under the experimental condition.

Setting and Participants

The participants in this study were students at a variety of elementary grade levels and socioeconomic levels located in different parts of Iowa, taught by experienced teachers completing their master's degree culminating action research project. This study was approved by the Human Subjects Committee of the overseeing university. All school principals approved the study; parents and students provided fully-informed written consent for student participation and for photographs of projects and students.

The first classroom was a fifth-grade classroom that contained 22 of the participants (11 male and 11 female). These participants ranged in age from 10 to 11 years old. There were 20 Caucasian participants, one Bosnian participant, and one Asian participant. The school the participants attended was the largest in the district that served families in a well-established suburban area. Families served in the school were upper middle class (5.32% eligible for free/reduced meals) when compared to other families in the district (24.23% eligible).

The second classroom was a suburban fourth grade classroom that contained 23 participants (8 male and 15 female). These participants ranged in ages from 9 to 11 years old. The participants' parents reported ethnicities were 21 Caucasian and 2 multiracial. The school of about 600 students (K-5) is one of 8 elementary schools in its district. Only 5.6% of families at this school are eligible for free/reduced meals.

The first of the third-grade classrooms is a rural third grade classroom that contained 16 participants (6 male and 10 female). These participants ranged in ages from 8-9 years old. The participants in this classroom were 100% Caucasian. These students came from a building of 189 students with 50.5% of them eligible for free or reduced-cost meals.

The second third-grade classroom was in the same building as the other third-grade classroom and was taught by the same researcher. This classroom contained 17 participants (8 male and 9 female). The participants also ranged from 8-9 years old and all identified as Caucasian.

Procedures

The daily procedures for the force and motion lessons are shown in Table 2. During this unit, students experimented with rubber band racers and marbles in rollercoaster tracks. Lesson procedures for the natural disasters unit are shown in Table 3. In this unit, students learned about a variety of natural disasters such as earthquakes, volcanos, landslides, tsunamis, floods, tornados, and hurricanes.

Table 2. *Lesson Procedures for the Force and Motion Lessons*

Day	Lesson Summary	Additional/Different Experimental Condition Component
1	Administer pretest	Same as Control Condition
2, 3, 4	Students make rubber band racers and experiment to figure out how many times to twist the rubber band to win the "Sweet Spot" race (Mystery Science, 2017).	Instead of a class discussion on findings, ask "If you wanted a wind-up car to go farther, what would you do?" Small groups create a short dance or kinesthetic demonstration to respond. Groups share. Instead of discussing ways to improve the design, students will quick draw their design improvement ideas and share.
5, 6, 7	Students explore how energy can be stored as height (potential energy). In the activity, they investigate how hills give roller coasters energy by experimenting with a model "bumper coaster" using a marble (Mystery Science, 2017).	Instead of only discussing which roller coaster is faster, Students act out the path of the white and red roller coaster. Instead of discussing what happened in the experiments, students act out what happened. Each student will be a marble for 2 explanations, and a narrator for 1.
8, 9, 10	Students investigate gravity by experimenting with dropping marbles from different heights and recording observations (Teachers Pay Teachers, 2016) Students investigate momentum by experimenting with dropping balls in different ways and recording observations (Teachers Pay Teachers, 2016). Students investigate friction by experimenting with matchbox cars and how they roll over different materials (Teachers Pay Teachers, 2016).	Same as Control Condition Students draw a picture of their results to the different trials instead of only writing an explanation. Students draw a picture of their example in addition to an explanation.
11, 12, 13, 14	Students explore how high the hills of a roller coaster can be. In the activity, students add hills to the Bumper Coaster they previously made and experiment to build a deeper understanding of hills and energy (Mystery Science, 2017). Students plan and begin building a bumper coaster. Students use a combination of the directions from Mystery Science, and the expectations from the STEM Roller Coaster Challenge guide to complete the task. Students continue to build and rethink their designs to meet the goal. Teacher gives group "inspections" while students are finishing up their designs.	Students design and use "billboards" along their bumper coasters explaining and identifying different energy and motion concepts. Concepts that must be included are gravity, momentum, and friction.
15	Administer Posttest	Same as Control Condition

Table 3. *Lesson Procedures for the Natural Disaster Lessons*

Day	Lesson Summary (30 min each)	Additional/Different Experimental Group Component
1	Administer Pretest	Same as Control Condition
2	Students learn the different types of natural disasters and hazards. Engineers have to understand these different threats because they must develop ways to prevent destruction from these events (University of Colorado Boulder, 2017; ideas from unit called Naturally disastrous). Control Condition: Write a description of one of the natural hazards and how it would affect people and communities.	Experimental Condition: Students will draw diagrams that show one type of hazard and create a sign that might warm people of a natural hazard around them.
3, 4	Students learn how earthquakes happen. Teachers demonstrate continental drift. Questions will be assigned to groups of students. (University of Colorado Boulder, 2017; ideas from unit called Earthquake formation). Control Condition: Students will take their question and discuss it with their group. They will present them to the whole group.	Experimental Condition: Students will write and act out a play based on discussion question that they are assigned.
5	Students learn the two major types of waves that are associated with earthquakes. Control Condition: Discuss the differences between the two types of waves (University of Colorado Boulder, 2017; ideas from unit called Earthquakes rock).	Experimental Condition: Demonstrate with student bodies the two types of waves (p waves and primary waves)
6	Students learn the causes and types of volcanoes. Students watch and measure a mock volcanic eruption and see the phases. Control Condition: Students write a persuasive paragraph about why a person should or should not live near one of these volcanoes (University of Colorado Boulder, 2017; ideas from unit called Volcanic panic).	Experimental Condition: Create a poster about each of the types of volcanos to help teach residents about the dangers/aspects of volcanoes.
7	Students learn about different types of landslides and why these different types occur. Students analyze the different factors that contribute to landslides. Students will create a mini landslide activity to test ideas. Control Condition: Look at photographs of landslides to determine type of landslide (University of Colorado Boulder, 2017; ideas from unit called Land on the run).	Experimental Condition: Analyze various photographs of actual landslides to determine possible causes of the landslides and artist/ photographer's purpose.

Table 3 Continued. *Lesson Procedures for the Natural Disaster Lessons*

Day	Lesson Summary (30 min each)	Additional/Different Experimental Group Component
8	Students learn about tsunamis and why they are dangerous. Students will watch a tsunami generator video to see how different materials are affected by tsunami forces (University of Colorado Boulder, 2017; ideas from unit Tsunami attack). Control Condition: Talk about different ways people in the past have prepared for tsunamis.	Experimental Condition: Look at historic art depicting tsunamis and analyze how people of the past may have prepared for or reacted to tsunamis.
9	Students learn about floods and look at the different types of floods that occur from different water sources. Students analyze the reasons why floods may have become more problematic recently as well as what solutions engineers have used to limit the destruction (University of Colorado Boulder, 2017; ideas from unit called Water, water everywhere). Control Condition: Discuss the differences between the types of floods.	Experimental Condition: Students create a safety flyer that would be passed out in a town within a floodplain. The flyer should educate citizens of the dangers but also about how they can protect themselves.
10	Students learn about the characteristics, damage, and occurrence of tornadoes. They look at how engineers structure buildings to withstand these strong winds. (University of Colorado Boulder, 2017; ideas from unit Tornado). Control Condition: Write a plan for what students would do in case of a tornado.	Experimental Condition Students create a short play that demonstrates what to do in case of a tornado.
11, 12	Students will be presented with the problem of building a structure that will withstand the effects of a hurricane. Students will have a list of materials they have to "buy." (University of Colorado Boulder, 2017; ideas from unit Build it better). Structures are tested. Control: Students create structure with no emphasis on aesthetics.	Experimental Condition: Students create their structure. Teacher will emphasize that these structures need to be designed in a way that someone would actually want to purchase or build this structure because of its aesthetic appeal.
13, 14	Presentations of structures and testing occurs. Students have various ways of preparing and presenting the information. Presentations must include key concepts that were learning and demonstrate their understanding of the unit as a whole. Control Condition: Students will present their structures and how they reacted to the testing.	Experimental Condition: Students create a mock news report about their structure and how it reacted to the testing including the rating of how their structure did.
15	Administer Posttest	Same as Control Condition

Instrumentation

Several types of instruments were used in the study. These are described here with instruments presented in tables.

Identical criterion-referenced pretests, posttests, and distal posttest. Before the study began, all students were given a criterion-referenced, teacher-made pretest of the content that would be learned in the coming weeks. According to Mills (2014), these teacher-made tests are especially good for action research in which random assignment of control or experimental group is not feasible. Identical posttests and distal posttests were used to test participants' content knowledge and retention following instruction. These assessments are shown in Table 4.

Table 4. *Pretest, Posttest, Distal Posttest Assessments*

Force and Motion Items	Possible Correct Response
1. What is gravity?	1. Gravity is the force that pulls an object towards the center of Earth.
2. How does weight of an object affect its speed of travel?	2. Weight does not affect the speed of an object, but it may give it more momentum.
3. What is momentum and how is it transferred between objects?	3. Momentum is the amount of energy an object has. It is transferred through collisions.
4. What effect does friction have on an object in motion?	4. Friction slows an object down.
5. How does acceleration affect an object in motion?	5. If an object is accelerating, its speed is increasing.

Table 4 Continued. *Pretest, Posttest, Distal Posttest Assessments*

Natural Disaster Items	Possible Correct Response
1. Describe how earthquakes form.	1. Earthquakes form when tectonic plates move against or away from each other.
2. Where are most volcanoes located, and what causes a volcano to erupt?	2. Most volcanoes are located in the Ring of Fire. Volcanoes erupt when pressure builds up.
3. How do tsunamis form and why are they so dangerous?	3. Tsunamis form when earthquakes occur on the seafloor. They are very dangerous because of the amount of water that they can push on land, and then the water recedes.
4. What is a landslide and how are they triggered?	4. A landslide is when a large amount of Earth or rock slides down a hill or mountain. They can be triggered by earthquakes, human actions, and too much precipitation.
5. What is a natural disaster that could occur where you live, and what precautions could you take to keep your family safe?	5. Answers will vary but may include floods, tornadoes, etc. Precautions may include going to a basement, having an emergency kit and plan, etc.

Instruments for scoring student constructions. Rubrics were used in the last week of teaching each of the two topics to evaluate participants' final projects on science content criteria as well as the creativity skill criteria. The scoring rubrics for roller coaster constructions is provided in Table 5 and the rubric for natural disaster construction is provided in Table 6. The content-related items were developed by the teachers to be criterion-referenced to the most important concepts taught that could be displayed in the projects. The creativity items included creative characteristics and strengths used in scoring the Torrance Tests of Creative Thinking – Figural (Torrance, Ball, & Safter, 1992). The ten creative traits that were most likely to be visible in student constructions were selected.

Table 5. *Rubric for Scoring Roller Coaster Constructions*

Science Content Criteria	Yes, Entirely (4 pts)	Mostly (3 pts)	Somewhat (2 pts)	A little (1 pts)	No (0 pts)
1. Gravity. The roller coaster displays gravity in the form of at least one hill.					
2. Momentum. The roller coaster's speed is controlled and the marble makes it from start to finish.					
3. Friction. There is an intentional use of materials to increase or decrease speed					
4. Met Expectations. The roller coaster has at least two loops and the marble does not fall off the tracks.					
Creativity Skill Criteria					
1. **Uniqueness.** Was this construction significantly different (in a positive way) from other student constructions in your class *at this time*?					
2. **Humor.** Was there an *intended* funny aspect to the construction?					
3. **Emotional Expressiveness.** Did the construction have people or a title that expressed emotion?					
4. **Word Play.** Was there word play in the title or in the construction?					
5. **Elaboration.** Was something done in an elaborate way (such as a lot of added details or complexity of parts)?					
6. **Fluency.** Does the scene have a lot of distinct parts?					
7. **Flexibility.** Did the construction show the science ideas in different ways?					
8. **Abstract Ideas**. Did the title present an abstract idea or was there symbolism involved?					
9. **Fantasy.** Was there evidence of story characters, famous people, a holiday event, pretending, involved in the construction?					
10. **Sound or Talking.** Were there callouts or sounds indicated or built into the construction?					

Table 6. *Rubric for Scoring Natural Disaster (Hurricane Shelter) Constructions*

Science Content Criteria	Yes, Entirely (4 pts)	Mostly (3 pts)	Somewhat (2 pts)	A little (1 pts)	No (0 pts)
1. Met Expectations. The family fits into the shelter, and the student stayed under budget.					
2. Rain. The student used materials that withstood heavy rain.					
3. Wind. The shelter was made to withstand heavy wind.					
4. Engineering Design Process. The student used the engineering design process to make adjustments to their structure.					
5. Vocabulary. Students used natural disaster vocabulary during their presentation.					
Creativity Skill Criteria					
1. **Uniqueness.** Was this construction significantly different (in a positive way) from other student constructions in your class *at this time*?					
2. **Humor.** Was there an *intended* funny aspect to the construction?					
3. **Emotional Expressiveness.** Did the construction have people or a title that expressed emotion?					
4. **Word Play.** Was there word play in the title or in the construction?					
5. **Elaboration.** Was something done in an elaborate way (such as a lot of added details or complexity of parts)?					
6. **Fluency.** Does the scene have a lot of distinct parts?					
7. **Flexibility.** Did the construction show the science ideas in different ways?					
8. **Abstract Ideas**. Did the title present an abstract idea or was there symbolism involved?					
9. **Fantasy.** Was there evidence of story characters, famous people, a holiday event, pretending, involved in the construction?					
10. **Sound or Talking.** Were there callouts or sounds indicated or built into the construction?					

Attitude survey instrument. Following each of the two topics, students were asked to take an attitude survey that used a ten-point scale to evaluate their feeling of enjoyment, creativity, perceived learning, and collaboration on a scale from 1 (not at all) to 10 (very greatly). An attitude scale was chosen because it allowed expression of what an individual believes, perceives or feels (Mills, 2014). With the use of an attitude scale, a Likert scale was chosen because of the ability to get a descriptive set of data while also providing a quantitative set of numerical data (Mills, 2014). The attitude survey for the force and motion lessons is shown in Table 7; the attitude survey for the natural disaster lessons is provided in Table 8. On the actual instrument, more room was provided for the student to explain his or her reasons for the ratings.

Table 7. *Attitude Survey for Force and Motion Lessons*

1. Circle a number below to show how much you enjoyed designing your roller coaster.											
Did not enjoy at all	1	2	3	4	5	6	7	8	9	10	Enjoyed very much!
Tell why:											
2. Circle a number below to show how creative you were in designing your roller coaster											
Not creative at all	1	2	3	4	5	6	7	8	9	10	Extremely creative!
Tell why:											
3. Circle a number below to show how much you think you learned from designing your own roller coaster											
Did not improve skills at all	1	2	3	4	5	6	7	8	9	10	Improved skills very much!
Tell why:											
4. Circle a number below to show how collaborative you were during the last three weeks in working with others.											
Not collaborative at all	1	2	3	4	5	6	7	8	9	10	Extremely Collaborative
Tell why:											

Table 8. *Attitude Survey for Natural Disasters Lessons*

1. Circle a number below to show how much you enjoyed designing your hurricane shelter.

Did not enjoy at all	1	2	3	4	5	6	7	8	9	10	Enjoyed very much!

Tell why:

2. Circle a number below to show how creative you were in designing your hurricane shelter.

Not creative at all	1	2	3	4	5	6	7	8	9	10	Extremely creative!

Tell why:

3. Circle a number below to show how much you think you learned from designing your own hurricane shelter.

Did not improve skills at all	1	2	3	4	5	6	7	8	9	10	Improved skills very much!

Tell why:

4. Circle a number below to show how collaborative you were during the last three weeks in working with others.

Not collaborative at all	1	2	3	4	5	6	7	8	9	10	Extremely Collaborative

Tell why:

Data Analysis

The analysis was conducted using data from the 78 students from grades 3-5 who completed all assessments (pretests, posttests, and distal posttests), attitude surveys, and projects, which were scored using the project rubrics. Means, standard deviations, *t*-tests, and Cohen's *d* effect size (if significant differences were found) were used to compare these scores across conditions.

Results

The purpose of this study was to determine if STEAM education has an impact on student attitudes and achievement. The results indicated teaching STEM with arts-integration (STEAM) was more effective than simply teaching through STEM. Overall, content scores on assessments, rubric scores, and student attitudes favored arts-integration.

Pretest, Posttest, and Distal Posttest Content

Each participant in the study was administered a pretest on each topic, a posttest after each instructional unit, as well as a distal posttest on each unit. Table 9 shows the mean scores of each assessment for each class of participants; assessments for each condition are shown side by side for easier comparison. Students' pretest scores showed significant differences on content that would be taught through different conditions; therefore, gain scores were used to evaluate the study. Gain scores indicate the amount of new knowledge gained as a result of the lessons and are calculated by subtracting the pretest scores from the posttest scores or the distal posttest scores.

Grade 4 and grade 5 classes showed significant gains in posttest gain and distal posttest gain scores in favor of the experimental condition. The fourth graders gained 36 percentage points in the control condition compared to gaining 54 points in the experimental condition from pretest to posttest. This difference in knowledge gained resulted in a large effect size. The fifth graders gained 25 percentage points in the control condition compared to 55 points in the experimental condition. This difference also produced a large effect size. The gain scores from pretest to distal posttest showed very similar trends with large effect sizes, indicating that students retained what they had learned well during the three weeks after the unit ended.

The content assessment results for the third grades contrast with the results for the older students. Mean content assessment scores of third- grade students either showed no significant difference between conditions (Class A posttest gains and both classes distal posttest gains) or favored the control condition on posttest gain scores (Class B), as shown in Table 7. The third-grade classes that participated in this study were used to a more traditional teacher-directed style of teaching in which creativity and collaboration were not typically a part of their school day. Because of this, the students may have had difficulty transitioning to this new type of learning within the sixteen weeks of the study, leading to a significant gain in favor of the control group of Class B and no significant difference of Class A.

One goal of this study was to research the effects of arts integration on sustained learning of STEM concepts. The data indicate that in the grade 4 and 5 classrooms, there was a significant difference in the retention of learning between the conditions in favor of the experimental conditions. The grade 3 participants showed no significant difference in mean scores from pretest to distal posttest.

Assessment scores in this study imply that the participants in this study, as a whole, showed more science content learning in the experimental condition. The assessment scores in this study indicate that teaching through arts integration supports science learning as well as or, in the case of the upper elementary students, better that typical instruction.

Table 9. *Mean Scores on Assessments for All Four Classes*

Mean Score	3rd Grade Class A Control Condition	3rd Grade Class A Experimental Condition	3rd Grade Class B Control Condition	3rd Grade Class B Experimental Condition	4th Grade Class Control Condition	4th Grade Class Experimental Condition	5th Grade Class Control Condition	5th Grade Class Experimental Condition
Pretest	0.07 (0.1)	0.17 (0.1)	0.09	0.18	0.35 (0.3)	0.22 (0.2)	0.50 (0.3)	0.25 (0.2)
Pretest paired *t*-test results	*p* = .006; significant difference; need to use gain scores		*p* = .045; significant difference; need to use gain scores		*p* = .001; significant difference; need to use gain scores		*p* = .0003; significant difference; need to use gain scores	
Posttest	0.50 (0.2)	0.60 (0.2)	0.66 (0.2)	0.50 (0.3)	0.71 (0.2)	0.76 (0.2)	0.75 (0.2)	0.80 (0.2)
Posttest paired *t*-test results	*p* = 0.01; significant difference favoring experimental condition; Cohen's *d* =0.50; medium effect size		*p* = 0.009; significant difference favoring control condition; Cohen's *d* =0.63; medium effect size		*p* = 0.15; no significant difference		*p* = 0.14; no significant difference	
Pretest to Posttest Gain	0.42 (0.2)	0.43 (0.2)	0.57 (0.1)	0.32 (0.3)	0.36 (0.2)	0.54 (0.2)	0.25 (0.3)	0.55 (0.2)
Posttest Gain paired *t*-test results	*p* = 0.42; no significant difference		*p* = 0.002; significant difference favoring control condition; Cohen's *d* =1.12; large effect size		*p* = 0.001; Significant difference favoring experimental condition; Cohen's *d* = 0.90; large effect size		*p* = 0.0004; Significant difference favoring experimental condition; Cohen's *d* = 1.18; large effect size	
Distal Posttest	0.44 (0.2)	0.53 (0.2)	0.49 (0.2)	0.48 (0.4)	0.75 (0.2)	0.79 (0.2)	0.76 (0.2)	0.80 (0.2)
Distal Posttest paired *t*-test results	*p* = 0.08; no significant difference		*p* = 0.43; no significant difference		*p* = 0.17; no significant difference		*p* = 0.21; no significant difference	
Pretest to Distal Posttest Gain	0.37 (0.2)	0.36 (0.2)	0.40 (0.2)	0.29 (0.4)	0.40 (0.2)	0.57 (0.2)	0.27 (0.3)	0.55 (0.2)
Distal Posttest Gain paired *t*-test results	*p* = 0.43; no significant difference		*p* = 0.15; no significant difference		*p* = 0.004; Significant difference favoring experimental condition; Cohen's *d* = 0.85; large effect size		*p* = 0.001; Significant difference favoring experimental condition; Cohen's *d* = 1.10; large effect size	

Note: Standard deviations in parentheses

Rubric Scores

During each condition, students were required to create a final project of a rollercoaster or hurricane shelter. Rubrics were used to grade the final projects based on science content criteria and creativity skill criteria. A four-point scale was used, with four being that the student entirely meets the expectation, and zero being the student did not meet the expectation at all.

The data in Table 10 shows the mean scores of final projects for each class in both the science content criteria and the creativity skill criteria. In two of the four classes (third grade Class B and the fifth grade class), the mean scores for science content criteria indicated a significant difference between the control condition and the experimental condition, with scores favoring the experimental condition with large or very large effect sizes. The other two classes showed no significant difference in science content scored with the rubric. Mean scores for the creativity skill criteria favored the experimental condition in all four classes with very large effect sizes. When both parts of the rubric were combined (both the content score and the creativity score), total rubric scores showed students scored higher on their final projects when integrating the arts with very large effect sizes.

Photographs of Students in Action

Figure 1 shows third-grade students and their hurricane shelters under two conditions. Figure 2 shows fourth-grade students working on hurricane shelters. Figure 3 presents fifth- grade students in action testing their hurricane shelters with water and hot blowing air.
Figure 4 shows third and fourth graders working on roller coaster constructions, while Figure 5 shows fifth graders working on roller coasters in the experimental condition. Figure 6 shows fourth grade students collaborating on their hurricane shelters in the control condition.

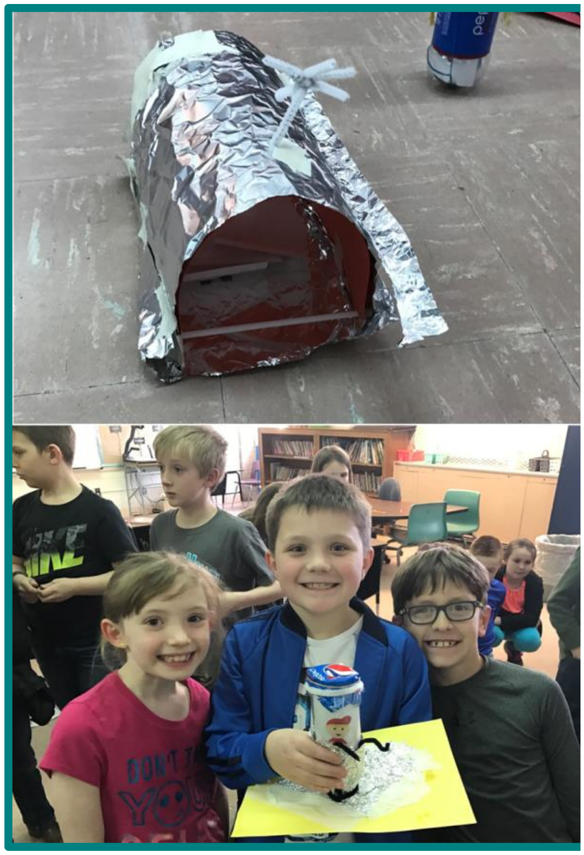

Figure 1. Third-grade hurricane shelters. The top photograph shows an example final hurricane structure in the third-grade experimental condition. These students used the pipe cleaners and foil as a way of shedding water while also maintaining the aesthetics of the structure. The bottom photograph shows third graders in the control condition getting ready to test their hurricane structure.

Table 10. *Mean Rubric-Scored Roller Coaster or Hurricane Shelter Product Scores for All Four Classes*

Mean Score	3rd Grade Class A		3rd Grade Class B		4th Grade Class		5th Grade Class	
	Control Condition Roller Coaster	Experimental Condition Hurricane Shelter	Control Condition Hurricane Shelter	Experimental Condition Roller Coaster	Control Condition Hurricane Shelter	Experimental Condition Roller Coaster	Control Condition Roller Coaster	Experiment al Condition Hurricane Shelter
Mean Score on Content Items (out of possible 4 points)	3.50 (0.0)	3.52 (0.2)	2.84 (0.2)	3.50 (0.0)	3.00 (0.2)	3.17 (0.5)	3.15 (0.6)	3.66 (0.6)
Paired *t*-test results	*p* = 0.36; no significant difference		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 4.66; very large effect size		*p* = 0.07; no significant difference		*p* = 0.005; Significant difference favoring experimental condition; Cohen's *d* = 0.85; large effect size	
Mean Score on Creative Characteristics (out of 4 possible points)	0.00 (0.0)	1.40 (0.0)	0.20 (0.2)	3.14 (0.1)	0.22 (0.3)	2.41 (0.5)	0.01 (0.0)	1.50 (0.3)
Paired *t*-test results	*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = infinity; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 18.6; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 5.64; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 7.02; very large effect size	
Mean Overall Product Score (out of 4 possible points)	1.00 (0.0)	2.00 (0.0)	0.95 (0.1)	3.24 (0.1)	1.02 (0.3)	2.63 (0.5)	0.91 (0.2)	2.12 (0.4)
Paired *t*-test results	*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 28.3; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 22.9; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 4.23; very large effect size		*p* < .0001; Significant difference favoring experimental condition; Cohen's *d* = 3.83; very large effect size	

Note: Standard deviations in parentheses

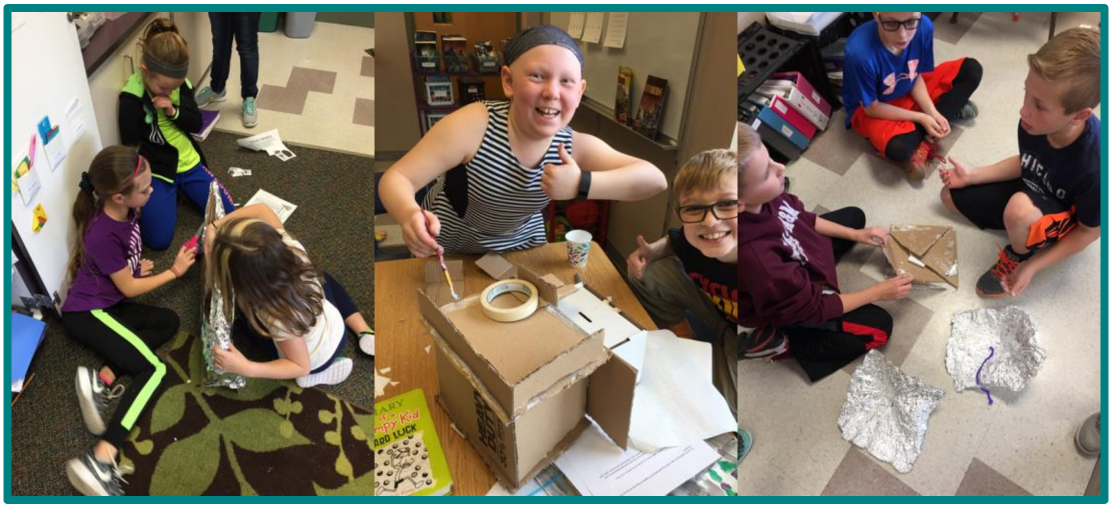

Figure 2. Fourth Graders working on hurricane structures during the control condition. Left and middle photos show students working; right photo shows students solving design flaws in their control condition hurricane shelter.

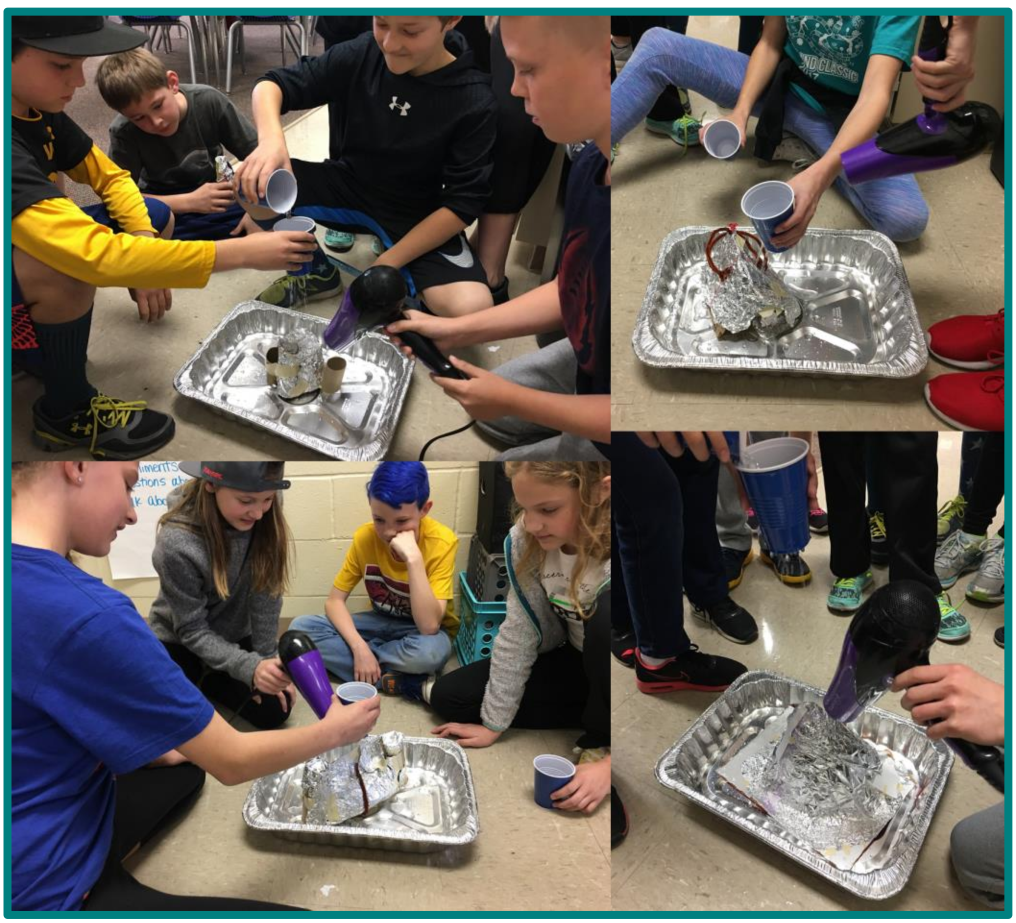

Figure 3. Fifth graders testing their hurricane shelter structures with pouring rain (water from cup) and blowing wind (hairdryer air). In the top left photograph, cardboard tubes were used to balance the shelter during the extreme wind. In the top right photograph, students used pipe cleaners to collect and guide the downpour or rain.

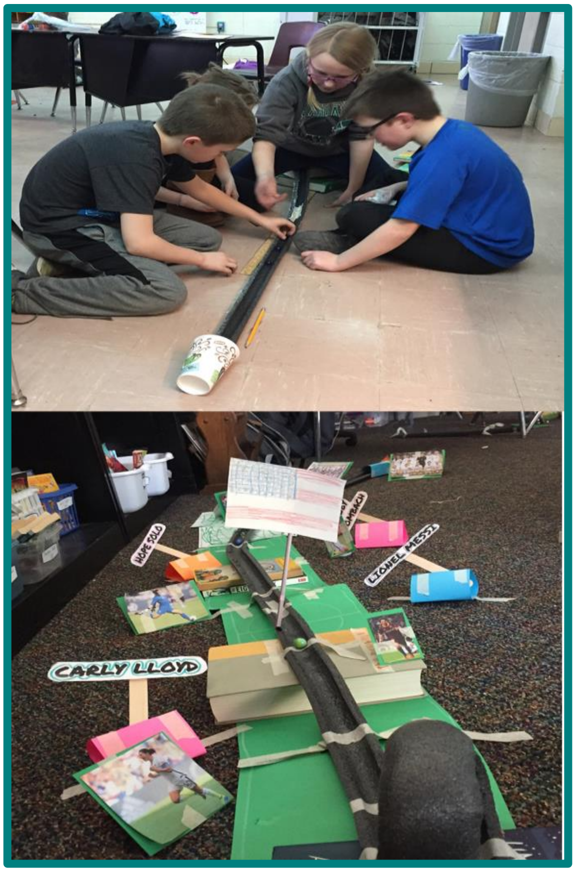

Figure 4 (at left). Students working on roller coaster constructions. Top photo shows third graders in the control condition. This group was testing aspects of their coaster as they continued to add to it. Bottom photo is an example of a final roller coaster project in the fourth-grade arts integration experimental condition. They decorated their roller coaster with images of athletes.

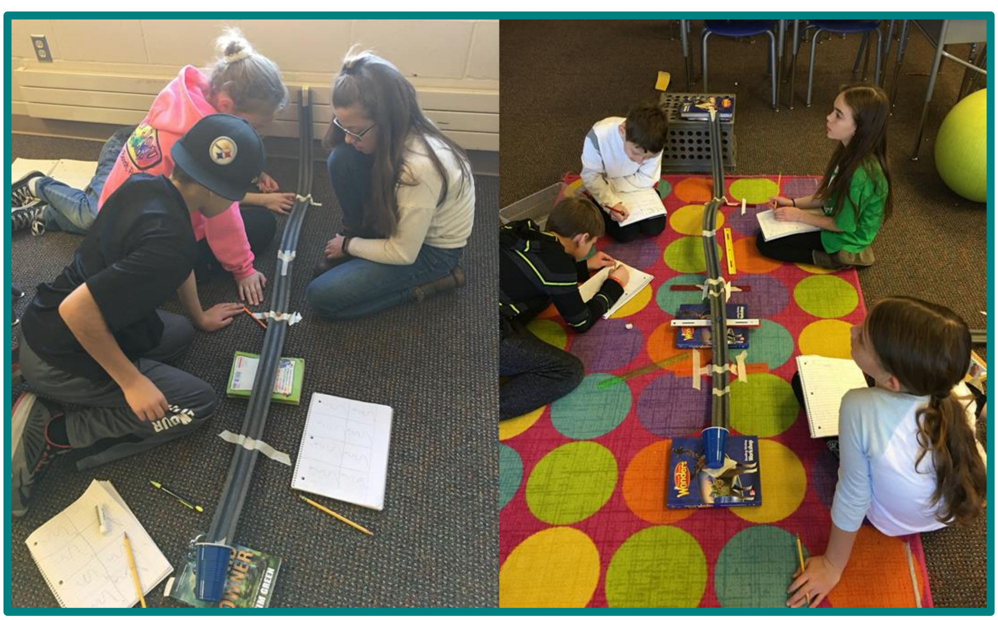

Figure 5. Fifth-grade students working on roller coasters under the control condition.

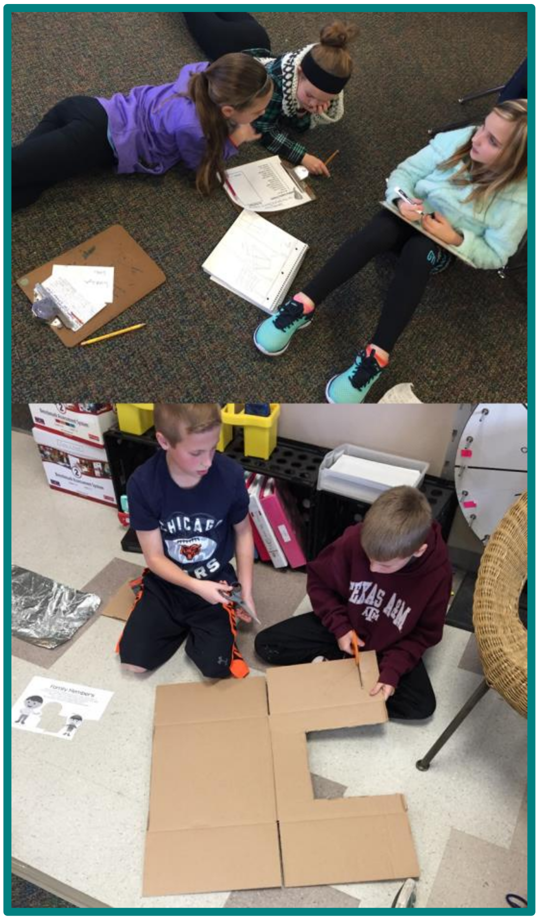

Figure 6. Fourth graders collaborating on building their control condition hurricane shelters.

Student Attitudes

Students in each of the four groups were given an attitude survey after learning each science topic. They were asked questions related to enjoyment, creativity, perceived learning, and collaboration. Students were asked to rate their response on a scale of one to ten, with one being not at all and ten being very much or extremely (depending on the question). The data in Table 11 shows the mean of student responses. In most cases, the data show no significant difference in scores between the control group and the experimental group. However, when students were asked to rate how creative they were, the data for fourth and fifth grades significantly favored the experimental condition of teaching STEM with arts-integration.

Discussion

The data collected from the current study were thought-provoking in several areas. First, differences between classes provided an interesting set of information. The data indicated that in both the fourth and fifth grade classrooms, students were able to improve more from their pretest scores to their distal posttest scores when instructed using an arts integration approach. This result supports the findings of Hardiman, Rinne, and Yarmolinskaya (2014) who measured the achievement of students learning ecology and astronomy with and without arts integration. These researchers found that there was a significant increase in student retention of the content for students in the experimental condition on the distal posttest, but not on the posttest, indicating that in the short term, students learned information under both conditions, but that arts integration made learning more salient in the long term. Differences between the current study and Hardiman et al.'s study were that the fourth and fifth grade classrooms showed significant difference in the posttest scores that favored the experimental condition. The posttest gain scores and distal posttest gain scores favoring the experimental condition in the fourth-grade class occurred because the students seemed much more engaged in the day to day lessons of the experimental group. The teacher observed student conversations indicating students had much less background knowledge in forces and motion as opposed to natural disasters.

Table 9. *Mean Ratings on Attitude Survey for All Four Classes*

Mean Score	3rd Grade Class A		3rd Grade Class B		4th Grade Class		5th Grade Class	
	Control Condition	Experimental Condition	Control Condition	Experimental Condition	Control Condition	Experimental Condition	Control Condition	Experimental Condition
1. Enjoyment rating	8.44 (2.7)	8.50 (1.9)	8.63 (2.14)	8.63 (2.1)	8.52 (2.1)	8.96 (1.5)	8.56 (1.9)	8.53 (2.6)
Paired *t*-test results	*p* = 0.47; no significant difference		*p* = 0.43; no significant difference		*p* = 0.22; no significant difference		*p* = 0.39; no significant difference	
2. Creativity rating	7.00 (2.7)	8.13 (1.9)	8.8 (1.9)	8.44 (2.6)	7.43 (2.3)	8.61 (1.8)	6.25 (2.0)	8.26 (2.9)
Paired *t*-test results	*p* = 0.06; no significant difference		*p* = 0.47; no significant difference		*p* = 0.03; Significant difference favoring experimental; Cohen's *d* = 0.57; medium effect		*p* = 0.02; Significant difference favoring experimental; Cohen's *d* = 0.80; large effect	
3. Rating of perceived learning	8.63 (2.3)	8.31 (1.8)	7.63 (2.7)	8.31 (2.3)	8.26 (2.1)	8.26 (1.8)	6.88 (2.4)	7.47 (2.8)
Paired *t*-test results	*p* = 0.30; no significant difference		*p* = 0.14; no significant difference		*p* = 0.50; no significant difference		*p* = 0.39; no significant difference	
4. Rating of collaboration	5.50 (3.2)	8.69 (1.8)	7.88 (3.5)	7.38 (3.6)	8.09 (1.8)	8.17 (1.9)	8.00 (2.4)	7.58 (3.2)
Paired *t*-test results	*p* = 0.0002; Significant difference favoring experimental; Cohen's *d* = 1.23; very large effect		*p* = 0.41; no significant difference		*p* = 0.40; no significant difference		*p* = 0.32; no significant difference	
Mean of all four ratings	7.39 (2.1)	8.41 (1.5)	8.22 (2.0)	8.19 (0.44)	8.08 (1.3)	8.50 (1.3)	7.42 (1.6)	7.96 (2.6)
Paired *t*-test results	*p* = 0.04; Significant difference favoring experimental; Cohen's *d* = 0.56; medium effect		*p* = 0.44; no significant difference		*p* = 0.10; no significant difference		*p* = 0.31; no significant difference	

Note: Standard deviations in parentheses

The greater engagement observations are supported by another study suggesting that students who are engaged learn and retain more content while enjoying learning activities more than students who are not so involved (Akey, 2006). Though the current study supports the engagement aspect of the Akey (2006) study, attitude survey results did not support Akey's enjoyment findings as there was no significant difference in conditions reflected on the student attitude surveys in the area of student enjoyment for any class. This difference in results between the two studies may stem from the engaging and satisfying construction activities employed under both conditions. Research indicates that students who are asked to conduct experiments, build models, participate in debates and role-playing, and complete projects are more likely to be engaged in their learning (Akey, 2006, pp. 5-6). Attitude surveys of the current study do support this idea as, in both conditions, students were asked to build something as a final project. Perhaps the hands-on construction activities also accounts for the lack of difference between conditions for the third graders. Their excitement of building roller coasters and hurricane shelters under both conditions may have overshadowed any other differences caused by arts integration.

Both third-grade classrooms provided somewhat anomalous results compared to the fourth and fifth grade classroom data. Third grade Class A did not exhibit a significant difference in distal posttest gain scores. The third grade Class B showed the anomalous result of a significant difference on posttest gain scores that favored the control condition of no arts integration. The fact that both conditions involved roller coaster and hurricane shelter constructions may be part of the cause of these unexpected results. Class B contained many students who needed more structure and the excitement of making constructions along with arts integration may have been too distracting. Starting this project earlier in the year to allow the students more exposure to using art in STEM learning may have better prepared students to focus on their learning rather than the novelty of the experiences. Students may have performed better within the control condition because of their lack of time to get accustomed to this type of learning and instruction.

Overall, the current study results confirm the findings of other studies on arts integration into science. As a whole, the current study showed that arts integration has the ability to do much more good than "harm" to student learning.

Conclusion

Data from the current study demonstrated significant differences in student achievement on assessments, project scores, and student surveys. Within the pretest, posttest and distal tests, the fourth and fifth graders showed a significant difference favoring the arts integration approach when comparing pretests to distal tests. Also, the fourth and fifth grade classrooms showed a significant difference in their creativity survey results that favored the experimental condition. These differences showed a strong tendency towards the art integration approach to teaching STEM, especially when working in the upper elementary grade levels.

Implications for Classroom Practice

Rather than teaching STEM in a traditional manner, the authors of this study highly recommend the integration of arts within STEM instruction for the upper elementary grade levels. Arts integration will likely increase student achievement and retention. Along with student achievement and retention, an art integration approach to teaching STEM had an increase on students' perception of creativity and collaboration while learning which is key to educating students that will eventually have careers in the STEM field.

Suggestions for Future Research

The authors of this study have a few suggestions for future research in this area. One of these suggestions includes attempting to find content topics for each condition of which all participants have little background knowledge. In the range of classroom ages, varying amounts of background knowledge on the topics were found, as shown by mean pretest scores on Table 2.1. To ensure more reliable and accurate results, it may be beneficial to find content topics that would produce more similar pretest results among participants. Because this research was conducted in real classrooms, it was found that some participants had similar content experiences in the past, even though district curriculums did not require it for the previous grade levels.

Another suggestion that may have contributed to the difference in classrooms is to ensure that both topics are equally abstract and factual. The content topics used in this study, force and motion and natural hazards, differ greatly. Force and motion concepts are more abstract, as natural hazards are more factual and concrete. This conceptual difference may have played a part in the difference between measures across the span of third to fifth graders in the current study.

One last suggestion would be to examine the different supports that would be needed to make this a positive learning experience for all ages of students. The current study only included grades three through five but this research could span across all grade levels if implemented appropriately. As we have seen in our data, the third-grade classrooms gave somewhat different results than the fourth and fifth grade classrooms. Because of these differences, the authors of the study would recommend a gradual implementation of arts integration into classrooms of third grade and lower. This may help students focus less on the change in routine and more on the art integration and content that is being taught.

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