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Investigating STEAM:
Integrating Art and STEM Education to Spark Innovation

Sara Hayman
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Abstract

The purpose of STEAM instruction in K-12 classrooms emphasizes the teaching of 21st century learning skills using innovative thinking to solve real-world problems and specifically combines the disciplines of Science, Technology, Engineering, Art and Math (Claymier, 2014; Gjovik and Skophammer, 2013). This study investigated how teaching children to recognize connections among subject areas using STEAM promotes innovation in students by using art to teach flexibility and fluidity in thinking. The goal was to determine if integrating art into a STEM project influences the attitude students have towards themselves and their abilities, their attitudes towards how different skill sets work together, and their attitudes towards the different STEAM subject areas. This research focused on fourth grade students from a rural elementary school in Northwest Arkansas, and a suburban school from the same area. Neither have had STEAM intervention. Only one class from each school, chosen at random, received the STEAM intervention. Both schools received the STEAM lesson within a month of one another. The lesson was taught in two sessions of two hours with both sessions being taught in the same week. The post-test was delivered by the researcher in the classroom immediately following the completion of the STEAM lesson. For the classrooms not receiving the STEAM lesson, the post-test was delivered by the classroom teacher. The research shows that when exposed to this method of teaching, students' interest in building things and investigating how things work increased. Student desire to become an artist, musician or actor increased along with an increased knowledge of the professions of engineering and art. Positive results unique to the suburban school included students having an increased belief in their ability to tackle problems without first knowing the answer, and picturing projects in their heads before building them. Scores increased when asked if students believed if artists make people's lives better. Scores for all

other survey questions decreased or remained the same. More research needs to be conducted on how STEAM instruction affects student learning over an extended period, and how it affects students' perceptions of their abilities to succeed in the other STEAM content areas.

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Introduction

The definition of the acronym STEAM is not always clear. There is ambiguity in the definition *from* person to person, but the main ideas of STEAM are to teach 21st century skills by placing learning into a context, creating opportunities for innovation, teaching flexibility in thinking using the arts, and to teach our students how to solve real world problems by combining science, technology, engineering, art, and math (Claymier, 2014; Gjovik and Skophammer, 2013). Integrating STEM knowledge and skills with creativity is required to be successful in a STEM career. To meet this need, the arts are being integrated into STEM education to create what is referred to as STEAM education (Oner, Nite, R. Capraro, M. Capraro, 2016). As educators and a nation, we need to clarify our goals for advancing STEM or STEAM education. Is it to beat other countries or is it to, as the STEM Education Caucus points out, to provide the country with three kinds of intellectual capital; scientists and engineers for development, technology proficient workers, and voters and citizens who can make intelligent decisions and can understand the world around them (STEM Thinking, 2015). If we want to advance innovation we need to restore the role of creativity, we need to teach our students what is being called “21st Century Skills” (Claymier, 2014). By integrating the arts and STEM we combine the skill sets that are learned in each area. The goal is to teach children problem solving skills, teach them these 21st century skills, and teach them to value what a different perspective learned from different subject areas can provide.

Background

A movement has occurred in America towards increasing STEM education, due to fears emanating from low national standardized test scores [as well as the general lack of innovation and creativity], so that American students will again be globally competitive and not fall any further behind (Daugherty, 2013). According to Kyung Hee Kim the more pressing problem is that we are experiencing a creativity crisis (Gjovik & Skophammer, 2013). We have never had the highest standardized test scores, but what we do have is "American Ingenuity." As a country, our specialty is innovating and combining great ideas to determine better ways of doing things (Gjovik & Skophammer, 2013). However, we are only ranked between 3rd and 8th in regard to international innovation currently, and the current mindset in our schools is that the arts are "nice, but not necessary" (Daugherty, 2013, p. 12).

Purpose and Significance of This Study

Studies focused on STEAM are sparse. This study was conducted to further investigate STEAM education in a formal learning environment**.** Specifically, the purpose of the study was to investigate how teaching children to recognize connections among subject areas using STEAM promotes innovation in students by using art to teach flexibility and fluidity in thinking. The goal was to determine if integrating art into a STEM project influences the attitude students have towards themselves and their abilities, their attitudes towards how different skill sets work together, and their attitudes towards the different STEAM subject areas resulting in the following research questions:

1. How does incorporating art into STEM education change students' perceptions of their abilities?
2. How are different STEM disciplines integrated in a real-life context?

Literature Review

The researcher conducted a review of the literature on the key components of STEAM and the implementation and teaching of 21st century skills. The 21st century skills include the four "C" s: creativity, critical thinking, communication, and collaboration. Problem solving skills, innovation, and invention are also necessary skills for real world transfer. The use of art in the classroom develops creativity, this creativity in turn leads to the development of divergent thinking, finally leading to the development of multiple solutions to a problem, another valuable skill in the 21st century. Researchers have pointed out the importance of artistic skills in the STEM workforce, and they include an interdisciplinary approach between problem solving, technology, innovation, and communication with multiple media tools (Oner et al., 2016). According to Tarnoff (2010), an executive looks to hire employees who "know how to collaborate in teams, express themselves coherently, engagingly, and persuasively, understand how to take and apply constructive cristicism, and how to tell a good story. I don't find these kids sitting alone at a lab table or buried in an algorithm. I find them taking art classes to understand how color and light really works" (Oner et al., 2016). Researchers have found that activities requiring creative thinking lead to enhanced self-reflection, advanced thinking skills, and the same strengthened collaboration skills Tarnoff mentioned in his description of desirable employees (Oner et. al, 2016). This literature review consists of an evaluation of the unique skill set that art adds to STEAM, the role of the teacher when adding STEAM thinking to the classroom, and the implications that the integration of STEM with the arts has for students.

Skills Taught in the Arts

Art uses what is called *studio habits of mind* or *studio thinking.* This studio learning model enhances skills in group collaboration, communication, and problem solving. The eight dispositions outlined in studio thinking can be applied across disciplines and in daily life. They involve (1) learning to use tools and materials, (2) embracing problems of relevance to learn focus, (3) picturing projects mentally, (4) conveying thoughts and ideas, (5) seeing things that might otherwise not be seen, (6) questioning and (7) explaining, and (8) relying on peers for insight (Daugherty, 2013). Art allows a person to follow their imagination and explore in a less constrained space which is what makes the combination of art and STEM so beneficial for innovation. It brings convergent and divergent thinkers together by combining art, technology, and design (using creativity for a purpose or function). Art helps put thoughts to paper through graphic means such as clay or sculpture, and gives a person a sort of "permission to pursue other experiences in a particularly focused way" (Daugherty, 2013, p. 12). Jay Young, a PhD student says that using the studio habits of mind helped him to understand math and science better by developing skills that enhance a person's abilities to create multiple solutions to a problem (Claymier, 2014; Daugherty, 2013). When using STEAM, curriculum is centered on design challenges that require students to solve problems multiple ways and in creative ways within the constraints of given criteria. The challenges can have varying degrees of constraints based on the end learning goals. Less constraints help foster creativity across the curriculum. Adding art to the curriculum and using design challenges in STEAM lesson plans fosters a unique set of skills among students, promotes careful observation of the world around them, and helps to expand the right hemisphere of the brain (Claymier, 2014; Daugherty, 2013).

Role of the Teacher

When using STEAM in the classroom, teachers must employ what is called STEM thinking (the design loop), but the researcher will modify it to STEAM thinking. It is essential to understand why STEM needs to change to STEAM. The combination of what seems like opposite content areas is what brings the variety and diversity necessary for fostering innovation in the classroom. For example, STEM employs logical, analytical, reproducible products and thinking whereas art employs subjective, intuitive, sensual, and unique thinking (Oner et al., 2016). Keeping in mind that the complement between science and art helps the teacher to promote system thinking among students by requiring them to consider all the parts that make the whole (Science, Technology, Engineering, Art, and Math); (STEM Thinking, 2015); (Oner et al., 2016). This interdisciplinary approach requires the teacher to remove subject area biases that may arise between academic and applied disciplines. The teacher will have to enhance understanding and communication among colleagues of different subject areas to best teach their students and integrate content areas. This requires teachers to become knowledgeable of STEAM subject areas (Claymier, 2014; Reeve, 2015). In the student-teacher relationship, the teacher models creativity, connects ideas between subject areas, and teaches skills in the context of content knowledge. Teaching STEAM uses student centered methods so lesson plans address high cognitive demands and potential classroom management problems. Reliable formative and summative assessments are needed for this new teaching style (Bass, Contant, & Carin 2009; McLaughlin, McLaughlin, & Pringle, 2013). Sometimes these assessments are referred to as performance assessments and can take the form of a performance that may be observed and/or a tangible product that may be examined (Bass, Contant, & Carin 2009). Examples include oral presentations, debates, exhibits, written products, construction of models, and solutions to problems all provide a means of assessing conceptual understanding while providing students with various opportunities to demonstrate their learning (McLaughlin, McLaughlin, & Pringle, 2013) These opportunities are necessary because often a STEAM lesson or project will cover the span of days or even weeks depending on the time allotted for work each day. Performance assessment tasks typically engage students in authentic, real-world, hands-on learning situations and impose high cognitive demands resulting in meaningful learning (Darling-Hammond, 2004). “Information provided by these assessments reveal student strengths and weaknesses, and help guide further instruction by teachers over the course of the project. In creating effective performance tasks, teachers should consider the following factors: the focus of the task, the context of the task, directions provided for the students and the rubric used for assessment. The focus of the assessment task should be closely aligned with the learning objectives and the context should provide a background and a question related to the focus objectives. Additionally, students must be provided with directions that clearly describe the performance and/or the product to be assessed as well as a scoring rubric for evaluating the quality of the performance task (McLaughlin et al, 2013)". Using these assessments can enhance the teaching of STEAM in a classroom and has the potential to create a nurturing environment of purposeful learning, increased self-worth and efficacy, creative collaboration, and open-mindedness. Through the explorative opportunities provided from STEAM learning, students have an increased chance of realizing potential and pursuing career options previously unknown to them or written off by them as unattainable or undesirable. Curt Bailey, the president of Sundberg-Ferar, one of the country's longest operating product innovation consulting firms, says, "In my industry, a designer who is oblivious to (or couldn't care less about) the science behind how something works will ultimately be limited in what he or she can accomplish. Likewise, an engineer or scientist who doesn't understand or appreciate beauty will be similarly handicapped. If students, from an early age, can be exposed to the equally magical results of great technology and great art, then all will be better prepared to leverage their individual gifts more effectively" (Bailey, 2015).

Implications for Students

The connections among subject areas included in STEAM promotes innovation in students by using art to teach flexibility and fluidity. STEAM is also beneficial because using hands-on and inquiry-based learning strategies challenges students to solve real world problems and explore curiosities. This type of teaching expands the U.S. centric mindset by focusing on a more global perspective. Projects requiring creativity with the knowledge of STEM disciplines, also known as project based learning, have gained popularity. One example of such a project would be using a 3D printer to design more sophisticated products. (Oner et al., 2016) STEAM education and the advantages of the arts provide several opportunities for students to improve themselves including development of cognitive growth, improvement of long-term memory, enhancement of social growth, reduction of stress, increasing the appeal of subject areas, and promotion of creativity. Research shows that including art in science fields increases students' interest in STEM fields. (Oner et al., 2016)

Methodology

The purpose of the study was to investigate how teaching children to recognize connections among subject areas using integrated STEAM learning promotes innovation in students by using art to teach flexibility and fluidity in thinking and to address the following research questions:

1. How does incorporating art into STEM education change students' perceptions of their abilities?
2. How are different STEM disciplines integrated in a real-life context?

Participants

This research is focused on two classes of fourth grade students, one from a rural elementary school and one from a suburban school in Northwest Arkansas. Neither have had STEAM intervention. The rural school reported some experience in STEM education while the suburban school has had minimal exposure to STEM. The first step in this research study was to identify which classes and teachers to include in the treatment. Next, the researcher sought approval from the University of Arkansas Institutional Review Board (IRB) (See Appendix A). All fourth-grade students at both schools were sent home with parental consent and student assent forms. The purpose of the study was explained to both parents and students in these forms. After the teachers received the completed forms, the students were given a pre-test by their classroom teacher. The forms and pre and post-tests were designed by the researcher and their faculty mentor (See Appendices B and C). The researcher developed the STEAM lessons, used for the intervention, in her Introduction to STEM (STEM 4033) course at the University of Arkansas. Only one class from each school, chosen at random, received the STEAM intervention. The researcher then taught the STEAM lesson in one class at each school that was determined to be the experimental group (See Appendices E and F). The lesson was taught in two sessions of two hours with both sessions being taught in the same week. The post-test was delivered by the researcher in the classroom immediately following the completion of the STEAM lesson. For the classrooms not receiving the STEAM intervention, the post-test was delivered by the classroom teacher. Both schools received the STEAM intervention within a month of one another. The goal was to determine if integrating art into a STEM project influences the attitude students have towards themselves and their abilities, their attitudes towards how different skill sets work together, and their attitudes towards the different STEAM subject areas. Participant confidentiality was ensured since the survey contained no identifying factors other than age, gender, and classroom teacher's name. All surveys and lesson documents were kept secure, and were only accessible by the researchers.

Intervention

In each intervention classroom, the researcher delivered the STEAM lesson. Day 1 of the intervention consisted of schema activation, delivering content information, describing to the students what the next two days would look like, and developing ideas for completing the project and solving the problem. The researcher displayed information in the form of a PowerPoint, showing students a timeline of the day. Students could look at and touch the materials they would be working with, but were not allowed to begin building. Students were introduced to the engineering design process. The students were required to brainstorm on their own, and then each group of 4 was instructed to come together to discuss individual ideas and combine them into one group plan. This was the first hour. The second hour students were given to design and build. The second intervention day consisted of class discussions on the previous day, finishing up projects, cleaning up, hosting a gallery walk where another class could view the projects. The students also completed peer and self-assessments at the conclusion of the project.

Data Collection

Data was collected and analyzed using Microsoft Excel. The data from the surveys was broken down by each school's pre-test and post-test results. Survey results were numbered with the answer of "agree" receiving a score of 3, "undecided" receiving a score of 2, and "disagree" receiving a 1(See Appendix D). Each individual student's scores were added together to give them some score out of a possible 33 for each set of questions on the survey. These were then averaged resulting in an average score for each set of questions for school's pre-test and post-test results. Differences in average scores and individual question scores were calculated for pre and post-tests results by school. The open-ended questions were briefly described and later categorized by themes.

Results

The purpose of this research was to examine how students' perceptions of their abilities change when incorporating art into STEM education, and how students perceive the individual STEM disciplines in a real-life context.

Demographics

In the suburban school district, according to the 2010 census, races can be distributed as; 83.8% are white, 6.0% are black or African American, 3.1% are Asian, and 6.4% are Hispanic or Latino. The school racial distribution is 3% American Indian, 18% African American, 0% Hispanic, 3% Asians/Pacific Islander, and 75% White. Within the intervention classroom there was an age range of 9-10 years old with the average age being 9.5. The class consisted of 60% male students and 40% female students.

In the rural school district, races can be distributed as 83% White, 8% Hispanic, 4% 2 or more races, 3% black, 1% Native American/Native Alaskan, 1% Asian, and 0% Native Hawaiian/Pacific Islander. The school racial distribution is 81% White, 10% Hispanic, 5% 2 or more races, 2% Black, 1% Native American, and 1% Asian. Within the intervention classroom there was an age range of 8-10 years old with the average age being 9.2. The class consisted of 42% male students and 58% female students.

Survey Comparisons

Before delivering the intervention, the mean pre-test scores were similar between the rural intervention classroom, suburban intervention classroom, and control classroom with scores being 26.58, 26.3, and 29.5 respectively (See Tables 1, 2, and 3).

Table 1

Results Obtained from a T-Test for the Rural Intervention School Surveys

Pre-Test		Post-Test				
N	Mean	N	Mean	t Critical two-tail	t Stat	P
24	26.58	24	25.04	2.03	0.917	0.36550768

*Note: The maximum score possible= 33 p>.05

Table 2

Results Obtained from a T-Test for the Suburban Intervention School Surveys

Pre-Test		Post-Test				
N	Mean	N	Mean	t Critical two-tail	t Stat	P
20	26.3	20	28.4	2.05	-0.913	0.36919879

*Note: The maximum score possible=33 P>.05

Table 3

Results Obtained from a T-Test for the Control Group Surveys

Pre-Test		Post-Test				
N	Mean	N	Mean	t Critical two-tail	t Stat	P
10	29.5	10	23.1	2.23	1.572	0.14698217

*Note: The maximum score possible=33

p>.05

The researcher received parental consent from 12 students in the rural school, 11 in the suburban classroom, and 5 from the control classroom. The survey contained two sets of questions, accounting for the number of observations. After the pre-tests and post-tests were delivered, results were analyzed using a two-sample assuming unequal variances t-test with an alpha level set at .05. This analysis revealed no significant differences between pre-test and post-test in either intervention classroom or in the control classroom.

The questions on the survey given to the students were classified into two categories: self and community. The questions pertaining to self (a student's direct relation with the STEAM content areas) studied the students' perceptions of their abilities and their connection to science, technology, engineering, art, and math. The questions about community (the connection between science, technology, engineering, art, and math and the world outside the classroom) examined what students think the STEAM fields can do for others and how the STEM fields are integrated in a real-world context.

Student Perceptions of Abilities

Breaking the survey down into two parts, the results for questions pertaining to self (the student) tended to be negative. The scores for the question "I am good at science," (asked each STEAM content area) went down at the rural school. For the questions "I am creative," "I like to start problems I don't know the answer to," and "I can picture projects in my head before I build them," the scores again went down. For the questions "I like how things work," and "I like building things," scores did go up between pre and post surveys (See Table 4).

Table 4

Rural School Results for Survey Question 1 Related to Self

Survey Question	Change from Pre to Post
I am good at Science	-0.18
I am good at Math	-0.10
I am good at Engineering	-0.01
I am good at Art	-0.20
I like learning how things work	0.04
I am creative	-0.07
I like to start problems I don't know the answer to	-0.04
I like building things	0.16
I can picture my projects in my head before I build them	-0.34

In the second half of the survey, questions again could be divided into community and self, but they also focused more on the professions of the STEAM areas and the future careers of students. When asked "I would like to be…" about all STEAM areas, science, and engineering, inventing, and designing machines scores went down. The students' responses to the questions "I would like to be an artist, musician, or actor," resulted in an increase in scores. The questions "I know what scientists (engineers and artists) do for their jobs," identified a decrease in scores for scientists, and an increase for engineers and artists (See Table 5).

Table 5

Rural School Results for Survey Question 2 Related to Self

Survey Question	Change from Pre to Post
I would like to be a scientist	-0.43
I would like to be an engineer	-0.38
I would like a job where I invent things	-0.21
I would like to be an artist, musician, or actor	0.07
I would like to design machines that help people	-0.05
I know what scientists do for their jobs	-0.08
I know what engineers do for their jobs	0.08
I know what artists do for their jobs	0.28

The results for questions pertaining to self at the suburban school were similar to those at the rural school. When students answered as to whether they thought they were good at math or engineering, the scores went down. When they answered whether they thought they were good at art there was no change in scores from pre to post survey with the mean score being a 2.7 (2 would be undecided and 3 would be agree to being good at art). Scores went down when asked if they thought they were creative, and there was no change when asked if they liked learning how things work. Scores went up in three areas: "starting problems that they don't know the answer to,"" building things," and "picturing projects in their heads before building them" (See Table 6).

Table 6

Suburban School Results for Survey Question 1 Related to Self

Survey Question	Change from Pre to Post
I am good at Science	0.10
I am good at Math	-0.20
I am good at Engineering	-0.04
I am good at Art	0.00
I like learning how things work	0.00
I am creative	-0.30
I like to start problems I don't know the answer to	0.30
I like building things	0.10
I can picture my projects in my head before I build them	0.10

The second half of the survey, revealed that students at the suburban school would like to be scientists, artists, musicians or actors, but when asked about being engineers, inventing, and designing machines, the scores went down from pre to post survey. These students also had scores that went down when asked whether they know what scientists and engineers do for their jobs. The scores remained the same when asked if they knew what artists do for their jobs (See Table 7).

Table 7

Suburban School Results for Survey Question 2 Related to Self

Survey Question	Change from Pre to Post
I would like to be a scientist	0.40
I would like to be an engineer	-0.20
I would like a job where I invent things	-0.20
I would like to be an artist, musician, or actor	0.20
I would like to design machines that help people	-0.20
I know what scientists do for their jobs	-0.10
I know what engineers do for their jobs	-0.10
I know what artists do for their jobs	0.00

Integrating STEM Disciplines

The survey also asked two open response questions; "What do you think engineers or scientists might make that could make a difference in your life (either good or bad)? Draw a picture with a label or make a list in the space below," and the same for artists and musicians.

At the rural school the responses pertaining to engineers and scientists could be categorized into two major categories with two outliers. These categories were medicine and current technology/robots for the majority with non-polluting travel, and a unicorn back support pillow being distinct from the majority categories. This can be seen in Figure 1.

Figure 1. Rural School Responses to Survey Question 1

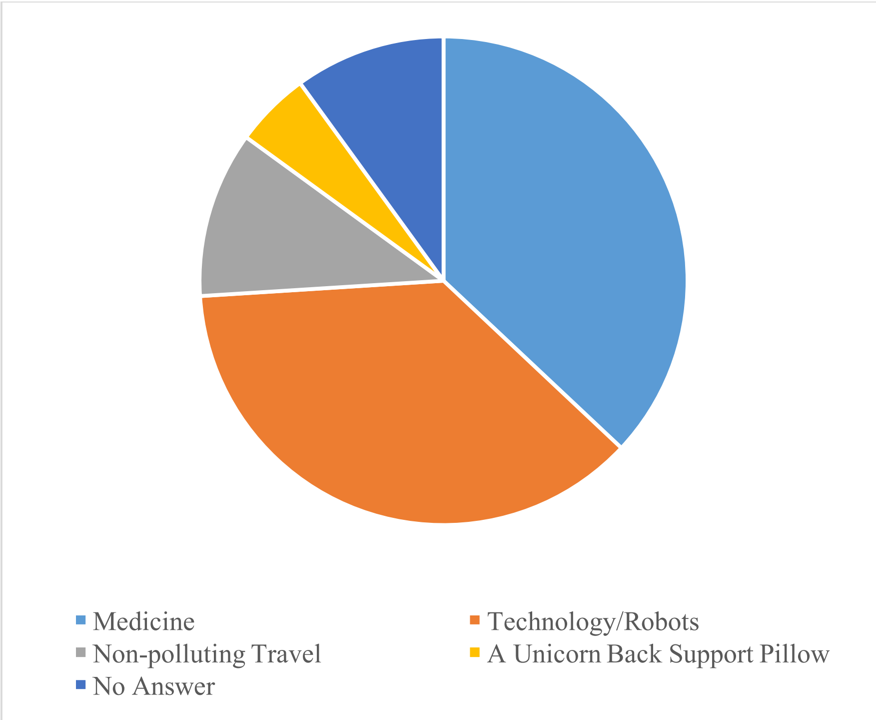

Figure 1. Responses from Rural School Participants to Survey Question 1 – What do you think engineers or scientists might make that could make a difference in your life (either good or bad)?

The responses pertaining to artists and musicians could be categorized into seven categories: good music for kids, music with a relation to technology (ways for playing music), artists/musicians doing good for others, Davinci and his machine, making art and music, teaching kids about art and music, and instruments. This can be seen in Figure 2.

Figure 2. Rural School Responses to Survey Question 2

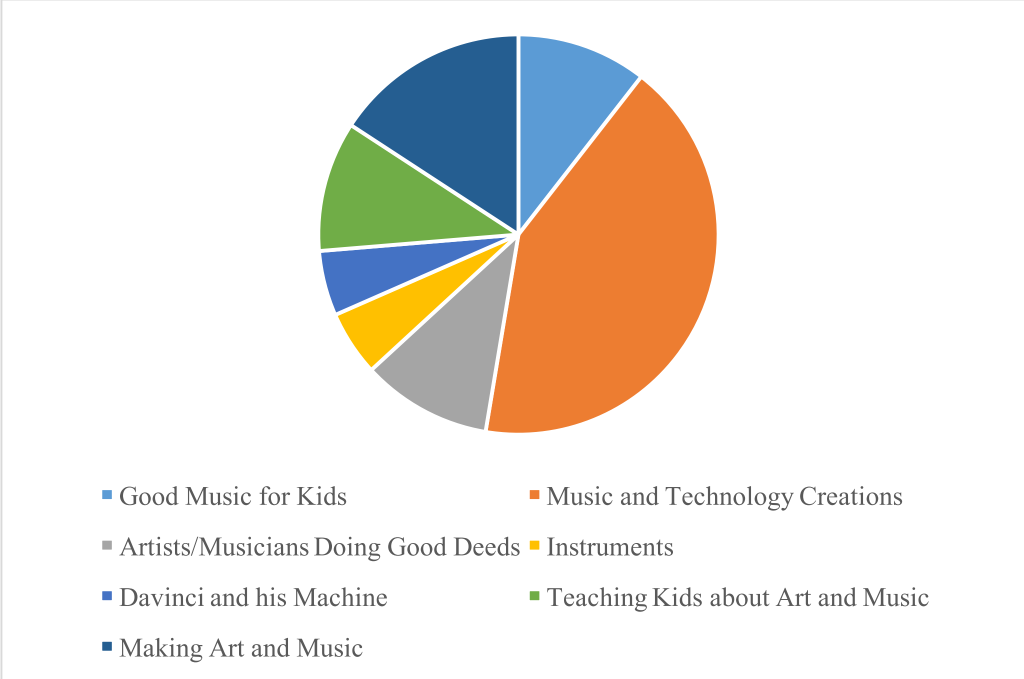

Figure 2. Rural School Responses to Survey Question 2– What do you think artists or musicians might make that could make a difference in your life (either good or bad)?

For the survey questions relating to community that could be answered disagree, undecided, or agree, children at the rural school had increased scores on the questions asking if science, math, engineering, and art could be used together, and again when asked if they thought art is as important as math, science, and engineering. However, when asked if scientists, engineers, and artists make people's lives better, scores went down (See Table 8).

Table 8

Rural School Results for Survey Questions Related to Community

Survey Question	Change from Pre to Post
I think that science, math, art and engineering can be used together	0.30
I think that art is as important as math, science, and engineering	0.04
Scientists help make people's lives better	-0.38
Engineers help make people's lives better	-0.08
Artists help make people's lives better	-0.11

At the suburban school, when asked if students thought that science, math, engineering and art could be used together, scores went down. Scores also went down when students were asked if they thought art is as important as math, science, and engineering. Scores went down for the questions asking if scientists and engineers help make people's lives better. Scores went up when asked if artists help make people's lives better (See Table 9).

Table 9

Suburban School Results for Survey Questions Related to Community

Survey Question	Change from Pre to Post
I think that science, math, art and engineering can be used together	-0.20
I think that art is as important as math, science, and engineering	-0.20
Scientists help make people's lives better	-0.20
Engineers help make people's lives better	-0.20
Artists help make people's lives better	0.10

For the open response questions, students at the suburban school wrote or drew things pertaining to medicine, time machines, current technologies, and robots when asked about what scientists and engineers might make, as seen in Figure 3.

Figure 3. Suburban School Responses to Survey Question 1

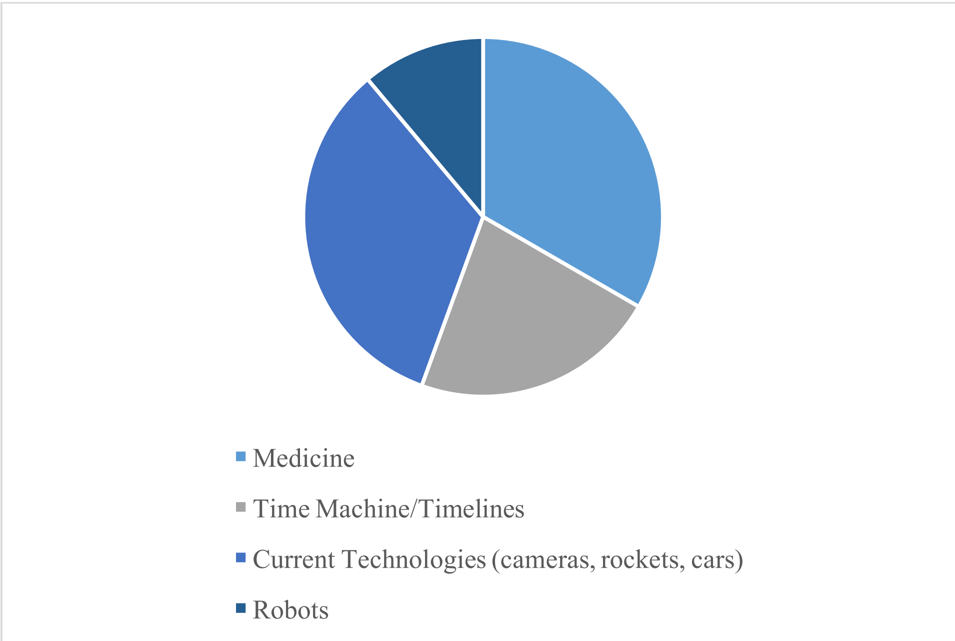

Figure 3. Responses from Suburban School Participants to Survey Question 1 – What do you think engineers or scientists might make that could make a difference in your life (either good or bad)?

For artists and musicians, students said that they might make good paintings/music, music and art that had a technological element to it, and books that combine music and art. This can be seen in Figure 4.

Figure 4. Suburban School Responses to Survey Question 2

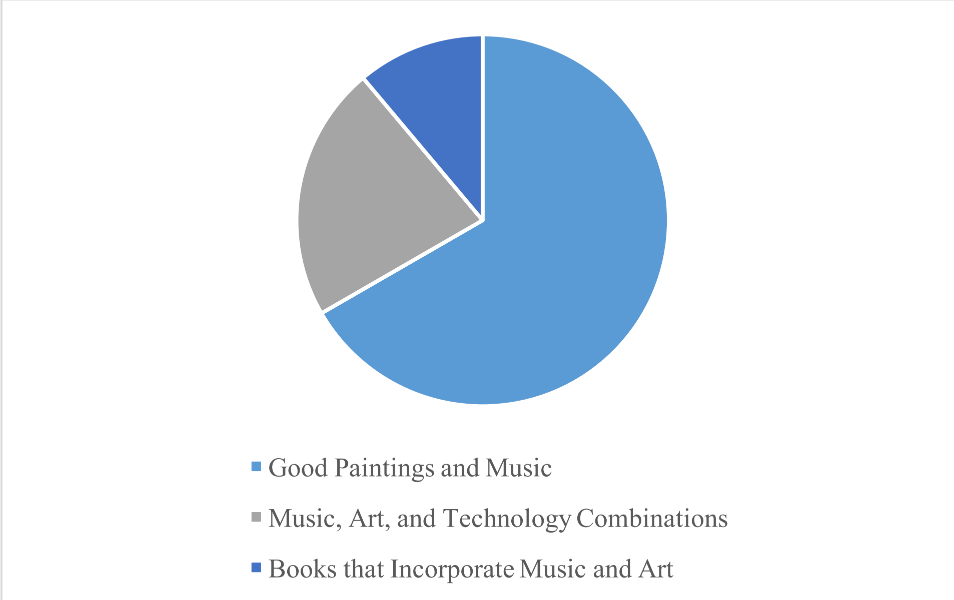

Figure 4. Responses from Suburban School Participants to Survey Question 2 – What do you think artists or musicians might make that could make a difference in your life (either good or bad)?

Figure 5. Selected Survey Question Results

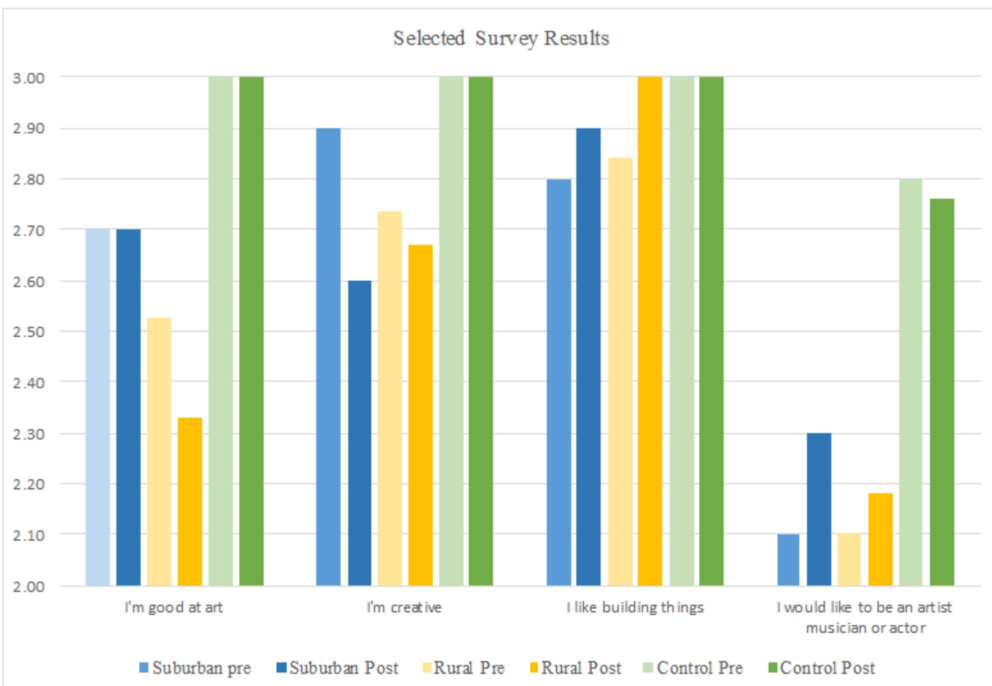

Figure 5. A comparison of a sample of questions among the suburban school, the rural school, and the control group.

These results reveal that students at both schools either remained the same in their thinking or had negative perceptions about their abilities in art and creativity after the intervention. Students' scores relating to building things and becoming an artist or musician increased in both settings. Overall, scores generally increased in relation to survey questions categorized as community, and decreased in relation to questions categorized as self.

Discussion

The purpose of the study was to investigate how incorporating art into STEM education changes students' perceptions of their abilities, and how different STEM disciplines are integrated in a real-life context while teaching children to recognize connections among subject areas using STEAM to promote innovation using art to teach flexibility and fluidity in thinking.

The data from the t-tests revealed that there are no significant differences in students' responses from pre-test to post-test when looking at the average scores from the entire survey. However, when looking at individual questions such as "I like building things," "I think that science, math, engineering, and art could be used together," and "I would like to be an artist, musician, or actor" a clearer answer to the research questions is given. Scores went up for all three of these questions in either the suburban schools, rural schools, or both (See Figure 5). Students see the value in using multiple subject areas together, and students can picture - themselves doing and using art. The study done by Oner, Nite, Capraro, and Capraro returned similar results (Oner et. al, 2016). Their individual comments from students revealed an awareness of the use of creative and artistic solutions in a variety of problem solving scenarios. Their literature review and study also supports the claims that participating in the arts enhances students' problem solving skills. Students in this study reported that they used their creativity in their STEM projects. Students see the value in an integrated curriculum, STEAM. Teaching using the model of project-based learning, and incorporating art into that is something students enjoy and is something that should have a presence in the classroom. It prepares students with 21st century skills in addition to the knowledge necessary to pursue careers in STEM fields.

Limitations

A few factors that limited the effectiveness of this study were the small sample size, limited time with students, students' previous exposure to both STEM and STEAM, and confusion in the matching of the pre-tests, post-tests, and parental consent forms. An extended study would alleviate many of these variables.

When conducting this study, the circumstances that likely affected the outcomes found at both schools included small samples from both schools due to a limited number of parental consent forms returned in addition to only one class at each school being exposed to a STEAM lesson. There was also some confusion involved in the classrooms with the procedure for matching pre and post-surveys. What had an even larger impact on the study was classroom access to previous STEM or STEAM learning environments, classroom management, and teacher confidence in facilitating an efficient collaborative learning environment.

For the suburban school, the class that received the STEAM lesson had never been to the STEM lab at their school. They had little experience with group work, the design process, and resource restrictions. This study exposed them to a new style of learning altogether when the engineering design process was presented. They were not only learning content from the STEAM areas, but they were also learning how to work in a collaborative group with time constraints, planning requirements, and constraints on materials.

At the rural school, the class receiving the STEAM lesson had been exposed to several STEM projects. However, they were not as open-ended as the STEAM lesson, they did not require as much creativity, and they tended to require convergent thinking while the STEAM lesson required divergent thinking. Students at this school wanted specific examples of what they could and could not do for their projects. The questions students asked implied a desire to create exactly what the teacher wanted instead of letting their creativity and the constraints identified in the student guide determine the boundaries of their projects (See Appendices E and F).

While the open-endedness of the project did not affect the students at the suburban school, students at both schools experienced some stress when exposed to a collaborative style of teaching and learning. There were new expectations associated with collaborative learning and divergent thinking that students had to learn in addition to content information. New teaching and learning styles take time to implement in a classroom, thus it was not surprising that students expressed a need for more time to adjust and practice this style of learning and creating.

The suburban school was undergoing a period of classroom management restructuring in the 4th grade. Prior to the completion of this study each classroom retaught the procedures and expectations for the classroom and the school. The noise level of students was hard to control, and keeping student focus was challenging for the researcher. These challenges cut into work time, and prevented some students from hearing the full instruction.

At the rural school, there were minimal classroom management issues. However, there were more students walking around the room, and students had to be refocused to return to their seats. This could be attributed to having a temporary and new teacher working with them.

When implementing a new learning style, specifically collaborative learning, there is an adjustment period for both teachers and students. Many teachers do not teach STEM because of the anxiety that sometimes comes with letting students take charge of their learning in a group setting. For many teachers, it is more logical to master procedures and independent work before allowing students to work in a collaborative and investigative setting, which may or may not be accomplished by the end of a school year. For this study, the researcher and both classroom teachers were new to the STEAM lesson design. The researcher and one classroom teacher were new to facilitating collaborative learning. The researcher was a pre-service teacher with limited in-classroom teaching experience.

Recommendations

Further research needs to be conducted on how using multiple subject areas together will affect student learning over an extended period, and on how it will affect students' perceptions of their abilities to succeed in the other STEAM content areas aside from art. In future research on this topic, a larger more representative sample should be collected. Data should come from multiple schools, grade levels, and districts in a geographical area that might be used to generalize the data to a larger population. This sample only considers students in the fourth grade in two Northwest Arkansas schools however a larger sample including multiple regions could show a difference in responses by region.

There is no significant positive connection between students' perceptions of their abilities and the introduction of art into STEM education based on this data. To gather a more accurate picture of students' perceptions, surveys could be given in a more controlled environment, much like reading testing. Data could also be collected by the researcher immediately before and after teaching a lesson as opposed to the classroom teacher delivering the surveys before the researcher arrived.

If this same study were conducted multiple times with the same researcher and teacher, it would be interesting to see if the introduction to a new teaching and learning style played less of a dominant role in the study. Replicating the study would allow for more control of outside variables unrelated to the study of students' perceptions of their abilities and of the arts. It would be noteworthy to gather data from teachers and administrators to examine their perceptions on creativity and how they are encouraging fostering such an important 21st century skill in the classroom. The educational background of both the teachers and the administrators could also have a large impact on the data collected based on whether they have had any specific training for fostering creativity, facilitating divergent thinking, and using collaborative learning in the classroom. When repeating this study, to ensure a sole focus on the effect of integrating art into STEM education students should beforehand have more opportunities to design, build, and create. This would lead to greater self-efficacy and confidence that, when at its lowest (when exposed to a new form of learning), would detract from the main point of the study.

More opportunities to design and build create

The more opportunities students are given to design, build, and create, the more willing to take risks they will be. To truly embrace the skills learned through the arts, students must be willing to fail and rework their design. This takes time. The more students work with the design process, using tools, and working collaboratively, the more unique creations they will produce.

Self-efficacy or Confidence

Familiarizing students with tool usage, and allowing them to draw on previous experiences will enhance the enjoyment students derive from STEAM projects. When students are engaged, and enjoying their work, a more accurate representation of their thoughts is provided. This self-efficacy could also be built by working with a researcher multiple times before delivering a post survey. To accurately represent student perceptions, a researcher needs to know the students, familiarize themselves with classroom procedures, and familiarize students with how STEAM learning works.

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Appendix A: IRB Approval

October 17, 2016

MEMORANDUM

TO:	Sara Hayman Vinson Carter Michael Daugherty
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	16-09-087
Protocol Title:	*Student Knowledge, Interest and Attitudes toward Science, Technology, Engineering, Art and Mathematics (STEAM) Education*
Review Type:	☐ EXEMPT ☒ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 10/14/2016 Expiration Date: 09/19/2017

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 120 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

Appendix B: Parental Consent

University of Arkansas
Consent for a Minor to Participate in a Research Study

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child's participation is voluntary. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form. We must also have your child's assent to participate in this study.

INVITATION TO PARTICIPATE
Your child is being invited to participate in a research study. Your child is being asked to participate in this study because we are evaluating the effectiveness of the program in regard to students' knowledge, interest and attitudes toward science, technology, engineering, art, and mathematics.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who is the researcher?

Sara Hayman, Honors Undergraduate Student, Early Childhood Education
Slh016@uark.edu (918) 760-0665

What is the purpose of this research study?

The purpose of the study is to determine if integrating art into a STEM project has an effect on the attitudes students have towards themselves and their abilities, their attitudes towards how different skill sets work together, and their attitudes towards science, technology, engineering, art, and mathematics (STEAM).

Who will participate in this study?

Approximately 120 elementary students in Northwest Arkansas.

What will your child be asked to do?

Your child's participation will require the following: Respond to survey questions two times during the course of the program. The surveys should take no more than 10-20 minutes to complete. The survey sample is attached. Surveys will be de-identified after data collection is complete. Some students will also participate in one STEAM project that will be delivered in two sessions at two hours each.

What are the possible risks or discomforts?

There are no anticipated risks to participating in this study.

What are the possible benefits to your child if he/she participates in this study?

There may be no direct benefits to the participants.

How long will the study last?

No outside class participation will be required. of the program) over the course of the semester. Students will be asked to complete two surveys (at the beginning and end The surveys will take no more than 10-20 minutes each.
Will your child receive compensation for time and inconvenience if you choose to allow him/her to participate in this study?

No.

Will you or your child have to pay for anything?

No, there will be no cost associated with your participation.

What are the options if I do not want my child to be in the study?

We would greatly appreciate your child's participation, but if you do not want your child to be in this study, you may refuse to allow him/her to participate. Your child may leave study (choose to have their pre/post removed from the study)

even if you give permission. Your child will not be punished or discriminated against in any way if you refuse to allow participation or if your child chooses not to participate.

How will my child's confidentiality be protected?

All information will be kept confidential to the extent allowed by applicable State and Federal law and University policy. Students will not put their names on the surveys, but a coding system will be used to match pre- and post-scores. The surveys will be de-identified at the completion of data collection and analysis.

Will my child and/or I know the results of the study?

At the conclusion of the study you will have the right to request feedback about the results. You may contact the researchers if you wish to see any results or would like feedback about the study. You will receive a copy of this form for your files.

What do I do if I have questions about the research study?

You have the right to contact the researchers for any concerns that you may have. Researcher information is listed above.

You may also contact the University of Arkansas Research Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP

Institutional Review Board Coordinator Research Compliance
University of Arkansas
109 MLKG Building Fayetteville, AR 72701-1201 479-575-2208
irb@uark.edu

I have read the above statement and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigators. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that significant new findings developed during this research will be shared with me and, as appropriate, my child. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.

I give permission for my child to be photographed when participating in this study. Photos could appear when the researcher publishes the results of this research study in a journal that requires photographs. The photographs will be used to illustrate the students completing the research intervention.

Yes No

Child name: ____

Print name: ____

Sign name: ____
Date:______________________

IRB #16-09-087
Approved: 10/14/2016
Expires: 09/19/2017

Appendix C: Child Assent

University of Arkansas

CHILD ASSENT TO PARTICIPATE IN RESEARCH

We are asking you to participate in a research study because we want to learn more about what you know and think about STEAM, which is science, technology, engineering, art, and math all woven together.

If you agree to be in this study, we will ask you to fill out a survey. The questions we will ask will not hurt you in any way and will only take about 10-20 minutes to answer. The answers you give may be shared with others; however, your name will not be on the answers and no one will know it was you who responded that way.

The information we learn from you participating in this study will help your teacher, and other teachers plan lessons in STEAM that will be fun and interesting for you.

Please talk this over with your parents before you decide if you would like to participate. We are also asking your parents to give their permission for you to participate.

You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me at (918) 760-0665.

Signing your name below means that you want to be in this study. You and your parents will get a copy of this form.

NAME OF STUDY PARTICIPANT

______________________	____________________	______________________
Printed Name of Participant	Signature of Participant	Date

I give you permission to photograph me when working in class on the STEAM project

Yes No

SIGNATURE OF PERSON OBTAINING ASSENT

In my judgment the participant is voluntarily and knowingly agreeing to participate in this research study.

Sara Hayman	(918) 760-0665
Name of Person Obtaining Assent	Contact Phone Number
______________________	____________________
Signature of Person Obtaining Assent	Date

IRB #16-09-087
Approved: 10/14/2016
Expires: 09/19/2017

Appendix D: Survey

STEAM Survey

1. Please mark how much you agree ☺ or disagree ☹. (😐 Means that you are not sure)

	☹ Disagree	😐 Undecided	☺ Agree
a. I am good at science.	☐	☐	☐
b. I am good at math.	☐	☐	☐
c. I am good at engineering.	☐	☐	☐
d. I am good at art	☐	☐	☐
e. I think that science, math, engineering, and art could be used together	☐	☐	☐
f. I think that art is as important as math, science, and engineering	☐	☐	☐
g. I like learning how things work.	☐	☐	☐
h. I am creative.	☐	☐	☐
i. I like to start problems I don't know the answer to.	☐	☐	☐
j. I like building things.	☐	☐	☐
k. I can picture my projects in my head before I build them	☐	☐	☐

2. What do you think engineers or scientists might make that could make a difference in your life (either good or bad)? Draw a picture with a label or make a list in the space below.

3. What do you think that artists or musicians might make that could make a difference in your life (either good or bad)? Draw a picture with a label or make a list in the space below.

4. Please mark how much you agree ☺ or disagree ☹. (😐 Means that you are not sure)

	☹ Disagree	😐 Undecided	☺ Agree
a. I would like to be a scientist.	☐	☐	☐
b. I would like to be an engineer.	☐	☐	☐
c. I would like a job where I invent things.	☐	☐	☐
d. I would like to be an artist, musician, or actor	☐	☐	☐
e. I would like to design machines that help people.	☐	☐	☐
f. Scientists help make people's lives better.	☐	☐	☐
g. Engineers help make people's lives better.	☐	☐	☐
h. Artists help make people's lives better	☐	☐	☐
i. I know what scientists do for their jobs.	☐	☐	☐
j. I know what engineers do for their jobs.	☐	☐	☐
k. I know what artists do for their jobs	☐	☐	☐

4. I am a:
   - ☐ Girl
   - ☐ Boy

5. How many years old are you?
   ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11

6. What grade are you in?
   ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

7. Teacher name: ____

8. ID number: ____

Thank You!

Appendix E: Lesson Plan: Teacher's Guide

Teacher Guide

Title: A Box of Happiness

Grade Level: 4th Grade

Standards:

Math-- A.R.Math.Content 4.MD.A.2 represent measurement quantities using diagrams such as *number line diagrams* that feature a measurement scale.
*We will represent measurement quantities with a bar graph

Science—
4-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and
constraints on materials, time, or cost.
4-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet
the criteria and constraints of the problem.
4-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify
aspects of a model or prototype that can be improved.

Technological Literacy—Standard 6 Students will develop an understanding of the role of society in the development and use of technology
Benchmark A: Products are made to meet individual needs and wants
Art—A.2.2 Transfer ideas and feelings to others through original works of self-expression using art elements and principles

Big Ideas:
Use design loop
Create a bar graph comparing effectiveness of group projects
Demonstrate how small pieces can be put together in multiple ways to serve different purposes
Create a design that can be changed and adapted to meet changing wants and needs
Use original works of art to transfer feelings of positivity and happiness

Essential Questions:
How can you create a work of art made up of recycled materials to meet the needs of the residents of your local nursing home?

Scenario (Hook)
Teacher will:
Prepare ahead of time different objects that can be created (1 for each group) (a mixture of art and structure)

For example, one group could make a tree house, one could make windmill, a flower (any of these could be 3D or flat on the table)

Provide each group of 4 students some recycled materials and ask them to create their assigned object in 10 minutes

Come together as a class

Ask students what they observe about all of the different creations

Introduce the idea that a great variety of objects can be built up from a small set of pieces

The Scenario: The local nursing home has reported increased complaints of boredom and sadness when sitting in the common room/game room. They have enlisted the help of our classroom to create an art piece to bring some happiness to the room.

Challenge
Create a 3-dimensional piece of art using recycled materials. Your project must be able to be displayed in a glass display case with dimensions of 18”x18”x18”. BONUS: Your art has moving parts.

Tools, Materials, Resources
Recycled materials (pizza boxes, straws, meat trays, paper plates, ketchup cups, craft sticks, fuzzy sticks, brads water cups, spoons, paint sticks)
Ruler/measuring tape
Scissors
Glue
12” of duct tape
Paint
Paint sponges
Design loop booklet
Excel (teacher material)
Survey sheets

Content Information

Bar Graphs: Students should have prior exposure and experience with bar graphs before this lesson, but you should remind students that bar graphs should include a title, a scale (vertical axis), scale label, categories (horizontal axis), category label, and data. It may be helpful to post a bar graph you have made as a class when giving these reminders. Explain that we might use a bar graph to help compare information about different groups. For example, we might use a bar graph to display how many votes each candidate received in an election or display the number of people who chose red, blue, or green as their favorite color.
Show a PowerPoint on a few different forms of art they could incorporate. Include examples and non-examples.

<u>Junk Art</u>
Artworks made from ordinary, everyday materials, or "found objects." Typically includes 3-D works like sculpture, assemblage, collage, or installations.

<u>Collage</u>
Composition consisting of various materials like newspaper cuttings, cardboard, photos, fabrics and the like, pasted to a board or canvas. May be combined with paintings or drawings.

<u>Sculptures</u>: Sculpture is three-dimensional artwork created either by (1) Carving- in stone, marble, wood, ivory, bone; (2) Modelling- from wax or clay; (3) Assembling "found objects."

<u>Using Excel to Make a Bar Graph</u>: At the end of the project, as a class create a bar graph displaying the results of your students' surveys (more information in procedures section). The teacher should run through the steps of making a bar graph prior to this lesson to refresh, and when the class makes the bar graph on excel think aloud as you guide your students through the steps. This is process is for exposure to excel, not for students to master the skill

<u>Procedures</u>

- Introduce the Scenario and Hook activity (15 minutes)
- Give students 30 minutes to handle the materials, come up with multiple designs, and choose a final design.
- Make sure students have filled out their engineering design books up to this point
- Have them discuss their designs with the teacher as they finish
- Give students 1 hour to complete design—End of work for the day
- In the next meeting have students display their work in a high traffic area
- As other students come by, ask them which one they like best, and put a tally on the sheet for that project
- After this is completed, return to the classroom and create a bar graph as a class
- Tell the class you will deliver their work to a nursing home over Christmas break
- Have a class exit discussion on what they learned and observed from their experiences
- Administer post surveys

<u>Deliverables</u>
Students will turn in:

- their completed design journal
- their art project
- their survey results
- their peer evaluations
- their self-evaluations

<u>Parameters or Constraints</u>

- Must finish in allotted time
- Must use allotted supplies for their group of 4
- Project must be under the specified 18"x18"x18"
- BONUS: Project has moving parts

Evalation/Assessment

Assessment will take place in the form of the self-evaluation and peer-evaluation.

Appendix F: Student's Guide

Student Guide

Title: A Box of Happiness

Scenario:

The local nursing home has reported increased complaints of boredom and sadness when sitting in the common room/game room. They have enlisted the help of our classroom to create an art piece to bring some happiness to the room.

Challenge:

Create a 3-dimensional piece of art using the recycled materials given to your group. Your project must have the dimensions of 18"x18"x18" or smaller. BONUS: Your art has moving parts

Tools, Materials, Resources:

- Recycled materials
- Rulers/ measuring tape
- Glue
- Scissors
- 12" duct tape
- Paint
- Sponge paint brushes
- Design loop booklet
- Excel (teacher material)
- Survey sheets

Big Ideas:

- Use design loop
- Create a bar graph comparing effectiveness of group projects
- Demonstrate how small pieces can be put together in multiple ways to serve different purposes
- Create a design that can be changed and adapted to meet changing wants and needs
- Use original works of art to transfer feelings of positivity and happiness

Essential Questions:

How can you create a work of art made up of the recycled materials to meet the needs of the residents of your local nursing home?

Deliverables

Students will turn in:

- their completed design journal
- their art project
- their survey results
- their peer evaluations
- their self-evaluations

<u>Parameters or Constraints</u>:

- Must finish in allotted time
- Must use the recycled materials allotted to each group of 4
- Project must be under the specified 18”x18”x18” measurement
- BONUS: Your project has moving parts

Peer Review		
Category	Agree	Disagree
Responsibility: My teammate contributed enough effort to help us finish the task		
Contribution: My teammate contributed to the success of the team, completed his/her share of the work, and offered constructive feedback to complete the tasks		
Team Performance: My team completed the task or finished a project accurately, on time, and according to specifications because all members contributed		
Team Collaboration: All members of our team carried out specific roles and contributed equally		
Communication: My teammate contributed to an effective team output, presentation, or communication effort		
My Name:		
My Teammate's Name:		

Self-Assessment		
Category	Agree (Why?)	Disagree (Why?)
<u>Learning:</u> From this assignment I learned that you can make many different things with few objects, and that these things can be disassembled to create completely new things		
<u>Communication:</u> I listened to the ideas my group members had, and really took them into consideration for the assignment.		
<u>Contribution:</u> I did the best I thought I could do on this assignment, and put in extra effort to make it great.		
This activity was engaging and really got me thinking about many different solutions.		
I felt like I was held accountable to get my portion of the work done, and felt like group work was helpful for my learning.		
Comments:		

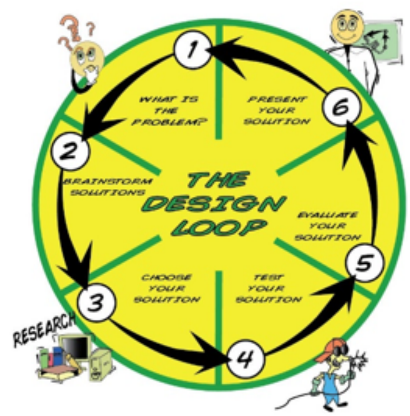
Sketch your final design or attach photo on backside of design loop!

What can I improve and share?

How did my design work?

What is the question asking? What are my parameters?

Engineering Design Loop



Initial ideas and sketches

My Idea Sketch

My Idea Sketch

Team Idea Sketch