Eighth Graders Explore Form and Function of Modern and Fossil Organisms

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Journal of STEM Arts, Crafts, and Constructions
Volume 2, Number 1, Pages 79-94.

The Journal's Website:
http://scholarworks.uni.edu/journal-stem-arts/

Abstract

Arts integration into science has been shown to motivate students and promote long-term retention of content. To add to the literature addressing arts integration, an experiment was conducted with middle school students studying the anatomical similarities and differences between modern and fossil marine invertebrates and different types of extant insects. Eighth grade students participated in a counterbalanced-design, quasi-experimental study to determine if the integration of art into the science curriculum would influence student retention of content, enjoyment, motivation, and perceived learning toward learning science concepts supporting the Next Generation Science Standards including engineering-related concepts. The lessons addressed Life Science standard MS-LS4-2. Results showed that the integration of an art activity had a significant effect on knowledge retention favoring the experimental condition with a medium effect size on the posttest and a large effect on the distal posttest. Student enjoyment, motivation, and perceived learning also showed significant differences overall and specifically for enjoyment and for perceived learning favoring the experimental conditions of arts integration with a small effect size.

Key Words

Fossils, insects, STEM Education, STEAM Education, pop-ups, art integration, middle school students

Introduction

With the current educational emphasis on the Core Standards (Iowa Department of Education, 2015) and STEM (Blackley & Howell, 2015), the focus on the arts has been reduced and in some areas, even eliminated (Wexler, 2014). As teachers work to cover an extensive amount of content, they constantly seek ways to help students retain information (Land, 2013). Researchers (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011) identified several teaching-learning mechanisms the arts naturally exercise that potentially benefit long-term memory. Later, three of these same researchers (Hardiman, Rinne, & Yarmolinskaya, 2014) published a study that showed how utilizing arts integrated science activities, compared to a control that taught the same science concepts for the same numbers of minutes in a non-arts way, had a significant positive effect on student retention of knowledge on a distal posttest.

The integration of the arts affects student enjoyment, motivation, and perceived learning. Authors of a recent study found increased enjoyment and motivation when integrating the arts with science (Olsen, Zhbanova, Parpucu, Alkouri, & Rule, 2013). Students "were enthusiastic, focused, on- task, and collaborative, and they even spontaneously thanked the teachers for allowing them to make pop- ups" (Olsen et al., 2013, p. 130). Increased learning is also a result of arts integration. Providing students with activities that connect with them emotionally, including the arts, created a deeper understanding of the content they were learning (Eisner, 1992). The integration of the arts helps students construct meaning for new concepts (Gullatt, 2008).

Literature Review

The current study explored the effects of arts integration using a quasi-experimental approach in eighth grade science classrooms. To provide a foundation for the current investigation, the recent literature on several pertinent topics is reviewed. Developments in the relatively recent movement to integrate the arts into STEM (Science, Technology, Engineering, and Mathematics) subjects are examined. The benefits of arts integration are addressed, including connections between arts integration in science and the effects on student retention, enjoyment, motivation, and perceived learning. The role of spatial learning, supported by the arts, as a support of the quasi-experimental research design is explained. The unifying theme of form and function that bridges the natural and designed worlds is then reviewed. Finally, national standards addressed by the lessons in the current investigation are discussed.

STEAM, Not STEM

While there is much support for the Science Technology Engineering Mathematics (STEM) movement in education, there is evidence that suggests that STEAM, with the addition of an "A" for integration of Art, is the more appropriate undertaking (Land, 2013). The emphasis on the core areas of STEM are definitely important, but focusing only on those ideas and excluding the artistic realm of human expression is denying students a creative and personalized connection with education. Land (2013) documented that recent college graduates are limited in their creative skills and self-motivation; with the technologies that are propelling work into the 21st Century, creative practice and innovative concepts are of primary importance (ASCD, 2008).

A key to improving these skills is promotion, through arts integration, of divergent thinking, instead of focusing only on convergent thinking (Land, 2013). Divergent thinking allows students to look for many possible answers to questions, providing them with opportunities for a vast exploration of ideas, instead of always relying on one, which narrows their exploration to focusing on a single idea. Divergent thinking to generate many design solutions is actually an important process skill for engineering, the "E" in STEM, so integrating the arts into curricula to support engineering practices makes sense. The interdisciplinary interaction of arts and science is a mutually beneficial practice (Bequette & Bequette, 2012). In addition to supporting the exploration of a variety of ideas through divergent thinking, arts integration with science supports other key engineering dispositions such as a tolerance for ambiguity, viewing design as inquiry, handling uncertainty, and decision making (Bequette & Bequette, 2012).

Benefits of Arts Integration

There is research supporting the integration of arts into various curricular areas (Perrin, 1994; Kelstrom, 1998; Gee, 2000; Reardon, 2005; Rabkin & Redmond, 2006; Gullatt, 2007). This research shows that arts integration can significantly benefit retention of learned information, student enjoyment, student motivation, and perceived learning. The authors of one article recommended eight mechanisms for arts integration to increase the potential for retention or long-term memory in students (Rinne et al., 2011). These authors identified the use of rehearsal, elaboration, generation, enactment, oral production, effort after meaning, emotional arousal, and pictorial representation as ways to engage students in content using the arts. They found that the benefits include positive effects for long-term recall of information, increased motivation, and greater mental processing (learning). "[E]nthusiasm for learning abounds when students build models, enter art contests, and create other art forms in the classroom" (Chudler & Konrady, 2006, p. 27). Enthusiasm indicates enjoyment and motivation in students. Student learning increases when students are able to create their own representations of what they're studying (Catterall,1998).

The integration of the arts has shown a positive influence on disadvantaged students and school readiness. An evaluation of forty-four studies (Robinson, 2013) concluded that arts integration has positive effects in some areas and potentially positive effects in others as well as being a strong support for Universal Design for Learning (UDL), which is a guide to creating curriculum that focuses on the individual needs of all learners instead of one prescribed plan for all students (Center for Applied Special Technology, 2014). Researchers in another study (Nevanen, Juvonen, & Ruismaki, 2000) found that arts integration improved children's school readiness and learning skills. Their results showed development in the children's enjoyment, motivation, concentration, problem solving, thinking skills, and social emotional skills.

Because there is still a significant division between the proponents of STEM and the proponents of STEAM, continued research is needed to clarify the role of the arts in the development of core curriculum. As educators strive to make data-driven decisions, the more known about how the arts affect student learning, the better curriculum decisions will be.

Spatial Thinking

Spatial thinking is important to the design of arts integration. Spatial thinking "concerns the locations of objects, their shapes, their relations to each other, and the paths they take as they move" (Newcombe, 2010, p. 30). Spatial thinking skills are an important benefit of the inclusion of the arts and provide a direct connection with STEM. Authors of a longitudinal study that tracked thousands of high schools students for eleven years, found that spatial abilities directly influenced choice of career and success in STEM disciplines and therefore must be included in the learning environment (Wai, Lubinski, & Benbow, 2009). Spatial thinking forms a gateway to the STEM disciplines by assisting students in acquiring foundational skills and helping them find alternate paths to some STEM concepts that are difficult to learn without using spatial thinking (Uttal & Cohen, 2012). These authors determined that spatial abilities could potentially prevent struggling students from dropping out of STEM programs. Educational STEM programs would benefit through the integration of the arts and the development of spatial thinking skills, providing the motivating and productive environment of STEAM.

Form and Function

Form and function is one of the big ideas or unifying concepts that connects both the natural and human-designed worlds. Science can be taught in a variety of ways; one way is through the use of a form and function analogy in which a form and function of an animal or plant part is compared to a similar form and function of a manufactured item. "*Form* is any physical attribute of an object such as shape, color, configuration, pattern of motion, texture, sound, smell, taste, and so forth. *Function* refers to the use, purpose, or task of a component" (Rule, 2015, p. 4). Utilizing form and function analogies encourages students to find the meaning of the different forms and requires they consider different ideas instead of simply focusing on one. This type of learning is effective in the teaching of science as it mirrors habits that are used by scientists and inventors in their work (Rule, 2015). Analogies help students make connections between their personal knowledge and the new information they are learning (Rule & Furletti, 2004). In addition to enhancing the learning environment for students, the use of form and function analogies has also been shown to increase student interest in and enjoyment of science activities (Rule & Welch, 2008).

Standards Addressed by the Project

The current study investigated the effects of arts integration in the eighth grade science classroom utilizing two of the new Next Generation Science Standards (National Academy of Sciences, 2013). One lesson involved the first part of this Next Generation Science Standard MS-LS4-2: "Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms" by having students choose two rainforest insects and explain anatomical similarities and differences between them (National Academy of Sciences, 2013). The other lesson addressed the second half of this Next Generation Science Standard MS-LS4-2: "Apply scientific ideas to construct an explanation for the anatomical similarities and differences between modern and fossil organisms to infer evolutionary relationships" through comparison and contrast of a modern sea organism and its fossil relative (National Academy of Sciences, 2013).

In addition to addressing the Next Generation Science Standards, this project also connected with two of the National Core Arts Anchor Standards (2014). The first was Anchor Standard #6: "Convey meaning through the presentation of artistic work" (National Coalition for Core Arts Standards, 2014). For the purposes of this study, the students in the treatment groups used art in the form of drawing and labeling to make the comparisons between their organisms. The second art standard utilized in this study was Anchor Standard #10: "Synthesize and relate knowledge and personal experiences to make art" (National Coalition for Core Arts Standards, 2014). To draw the organisms, students combined what they learned through research with what they knew personally about the organisms to draw and label their sketches. The utilization of the arts standards was very important for this study. The focus of the study was determining what effects the use of the arts would have on a science lesson. Using the arts standards provided the artistic lens for the drawings integrated into the lessons.

Method

The purpose of this study was to determine if the integration of arts into an eighth grade science class makes a difference for the students in terms of their retention of information as well as their enjoyment and motivation toward and perceived learning of science.

Research Questions

There were two research questions addressed by this investigation:

1) Do students retain learned core information longer if arts are integrated into the lesson? The answer to this question was determined with pretests, posttests, and distal posttests of content information learned under the control condition and the experimental condition of arts integration. Students were given a pretest prior to each lesson, a posttest after the completion of each lesson, and a distal posttest one month after the completion of the second lesson.

2) How does the integration of the arts in a core class affect the students' enjoyment and motivation concerning the lesson and also perceived learning of the lesson content? The answer to this question was determined with a survey, which was taken after the completion of both lessons.

Setting and Participants

This study took place at a medium-sized middle school in northeastern Iowa. The study was conducted in the six sections of the eighth grade science courses being taught at the school. The morning classes were in the controlled condition for the first lesson and the experimental condition for the second lesson, and the afternoon classes were in the experimental condition for the first lesson and the control condition for the second lesson. The study took place during four days in one week of instruction. Each lesson spanned two days.

The study was approved by the Internal Review Board Human Subjects Committee of the overseeing university and by the principal of the school involved. All participants were fully informed of the nature of the study. There were 128 students total in the six course sections. Signed consent for participation was obtained from 93 students and their parents (51 female, 42 male), but only 32 students (15 female, 17 male) participated fully and completed the pre-test, posttest, and distal posttest. Reasons for incomplete participation of those who had provided consent included student absences for various reasons, a mobile student population with students moving away from the school district, and incomplete work. Because of this situation, only complete content assessment data from the 32 students who completed the pretest, posttest, and distal posttest were reported in the analysis.

Contrary to the lack of completion of many of the content assessments, all 93 students who provided signed consent participated fully in the survey of enjoyment, motivation, and perceived learning. For clarity of impact on all 93 students, but also to compare survey data of the group of 32 students participating in all content assessments, survey data are included in two ways: 1) for all 93 students who completed the survey and 2) limited to the same 32 students reported for the content data.

Research Design

This investigation had a counterbalanced, pretest, posttest, and distal posttest, quasi-experimental design. “Counterbalancing is a general technique for eliminating the serial effect of order for tests, treatments, and so on” (Krathwohl, 2014, p. 439). Utilizing this repeated measures design provided comparative data for the eighth grade science students without requiring a separate control population. The identical, open-ended pretests and posttests provided information about what the students learned during each lesson and condition because the questions on the instrument were directly tied to the topics of each lesson. There was no overlap between the content of the two lessons, as one focused on fossil marine organisms and the other focused on modern insects from the Amazon River basin. For measurement of long-term retention, we used distal posttests. A study conducted by Rinne, Gregory, Yarmolinskaya, and Hardiman (2011) revealed no difference on the regular posttest but a large difference later on the distal posttest. Therefore, a distal posttest was administered one month after completion of the two lessons to test for this possible effect.

Surveys of student enjoyment, motivation, and perceived learning were also given at the end of the lessons. These surveys measured how much the student enjoyed the activities in the lessons, how motivated each felt to do the science work, and how much each felt was learned from each lesson.

Students in several eighth grade science classes participated in the two lessons. In one lesson, the control condition, they did an online comparison chart. In the other lesson, the experimental condition, they drew and labeled pictures and then created pop-up constructions in file folders to show the comparisons.

Lesson Procedures

The 5E science lesson model of engage, explore, explain, expand, and evaluate was used for planning these lessons (Sally Ride Science, 2016). During Lesson 1, all students compared two insects from the rainforest under either the arts-integrated, experimental condition in which they sketched the organisms and made a pop-up display or the control condition in which they made an online comparison chart. During Lesson 2, all students compared a modern marine organism to its fossil relative under either the arts-integrated, experimental condition in which they sketched the organisms and made a pop-up display or the control condition in which they made an online comparison chart. Students who were in the control condition for Lesson 1 then experienced the experimental condition for Lesson 2 and vice versa for the other group in this counterbalanced design. Each condition was on a different topic and the pretests and posttests addressed those topics separately, so there was no contamination of learning from one topic to the other. This design can be seen in Table 1, which provides details that show the separation of the classes by control conditions and experimental conditions and what they did in each of the lessons.

Instrumentation

One content instrument was used as a pretest, posttest, and distal posttest. The assessment was based on constructed response questions and drawings. The first two questions addressed content learned in Lesson 1: Rainforest Insects. The first question was constructed response asking the students to name two rainforest insects and identify three similarities and three differences between them. A chart was included to help the students answer the question. The second question asked the students to sketch a detail of a specific part of one of the rainforest insects, explain how its form supports its function, and label the sketch. The next two questions addressed content learned in Lesson 2 on Marine Organisms. The first of these questions (question 3) asked the students to name a modern and a fossil marine organism and to identify three similarities and three differences between them. A chart was provided to help them organize their responses. The next question (question 4) asked students to sketch a detail of a specific part of a marine fossil, explain how its form supports its function, and label the sketch. This instrument was used for the pretest, posttest, and distal posttest.

The survey of student enjoyment, motivation, and perceived learning included three rating scales and three constructed response questions. The constructed response questions asked students to explain the rating the student gave. The first question asked the students to circle, on a scale of 1 (did not enjoy at all) to 10 (enjoyed very much), a number to indicate how much they enjoyed the activities in the lesson. This item was followed by a question asking the student to explain why he or she gave that rating.

The next question asked the students to circle, again on a scale of 1 (not motivated at all) to 10 (very motivated), how motivated they felt to do the science work in the lesson. This item was also followed by a constructed response question asking students to explain why they chose this rating. The next question asked the students to circle, again on a scale of 1 (did not learn at all) to 10 (learned a lot), a number to indicate how much they felt they had learned from the science lesson. It was also followed up with a constructed response question asking students to explain why they chose the number they chose. All of these questions were asked about Lesson 1 Modern and Fossil Marine Organisms Lesson and Lesson 2 Rainforest Insects.

Table 1. *Structures of the Lessons*

Lesson	Condition	Classes	Activities that are Constant	Activity Parts that Vary with Condition
Lesson 1 involved the first part of this NGSS standard: "Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms" by having students choose two rainforest insects and explain anatomical similarities and differences between them.				
1	Experimental Condition	Morning Classes	1. Chose two modern insects from the tropical rainforest environment to study. 2. Researched details about the two chosen insects.	Students created a pop-up folder identifying two chosen insects identifying similarities and differences associated with their forms and functions.
1	Control Condition	Afternoon Classes	3. Compared the similar forms and functions of the two insects.	Students wrote descriptions of two chosen insects and charted similarities and differences associated with their forms and functions in an online comparison chart.
Lesson 2 addressed the second half of this NGSS standard: "Apply scientific ideas to construct an explanation for the anatomical similarities and differences between modern and fossil organisms to infer evolutionary relationships" through comparison and contrast of a modern ocean organism and its fossil relative.				
2	Control Condition	Morning Classes	1. Chose a modern invertebrate from ocean environment organisms. 2. Student researched information about the modern ocean organisms. 3. Researched possible fossil ancestors of the modern organism.	Students wrote descriptions of a chosen modern ocean organism and a possible fossil ancestor and chart similarities and differences associated with their forms and functions in an online comparison chart.
2	Experimental Condition	Afternoon Classes	4. Compared similar forms and function of the two organisms.	Students created a pop-up folder identifying a modern ocean organism and a possible fossil ancestor identifying similarities and differences associated with their forms and functions.

Data Analysis

Student assessment scores for content, survey ratings, and reasons given for survey ratings were entered into a spreadsheet for analysis, calculations, and sorting. For the quantitative date, means, standard deviations, and t-tests were conducted with effect size calculated for significant differences. For qualitative data, sorting functions were used to gather data into categories using a constant-comparative method (Glaser, 1965).

Results

Student Process

Students began researching the insects and marine organisms in both control and experimental conditions. As students collected information in the control condition, they documented their notes about the rainforest insects' or marine organisms' forms and functions followed by their similarities and differences in an online comparison chart, a Google document generated by the teacher. Students in the morning classes experienced the control condition studying the marine organisms, and students in the afternoon classes experienced the control condition studying the rainforest insects.

In the experimental condition, students documented their notes about the insects or marine organisms' forms and functions on the covers of their folders. They documented the similarities and differences using the pop-ups inside the folder. Students drew the forms on the tops of the pop-ups to be seen when pop-ups are closed. Students explained the function of the form inside the pop-ups to be seen when pop-ups are open. Students also identified which forms and functions were similarities or differences between the two rainforest insects or marine organisms. Students in the morning classes experienced the experimental condition studying the rainforest insects, and students in the afternoon classes experienced the experimental condition studying the marine organisms.

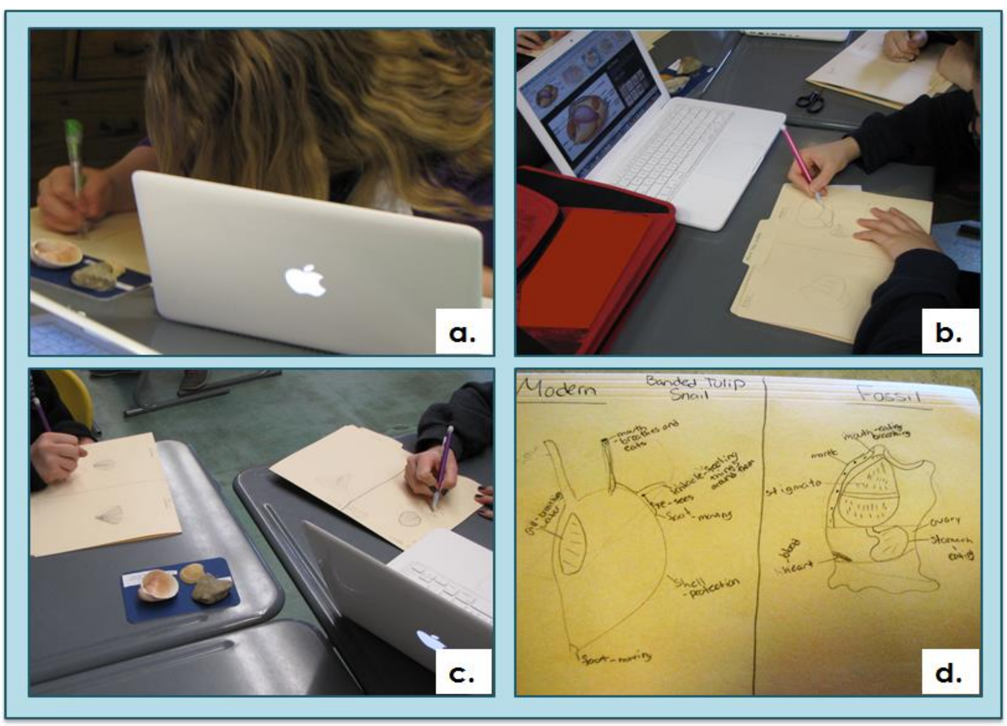

Figure 1. In the experimental condition, students research information (1a), draw and label (1b, 1c) the covers of folders with information about the organisms (1d).

In the control condition, students completed a task that was very familiar to them. They had completed charts on their computers for other assignments and projects. For those students who enjoy working on the computer, this was very enjoyable. This computer work may have affected the data on enjoyment of the control condition compared to the experimental condition. The results might have been different (students in the control condition may have found less enjoyment) if students had been asked to complete charts with pencil and paper.

The experimental condition provided a unique task for the students beyond the research of learning about the organisms' body parts. The students were not accustomed to drawing, cutting, pasting, or creating craft projects to learn or exhibit their learning of science.

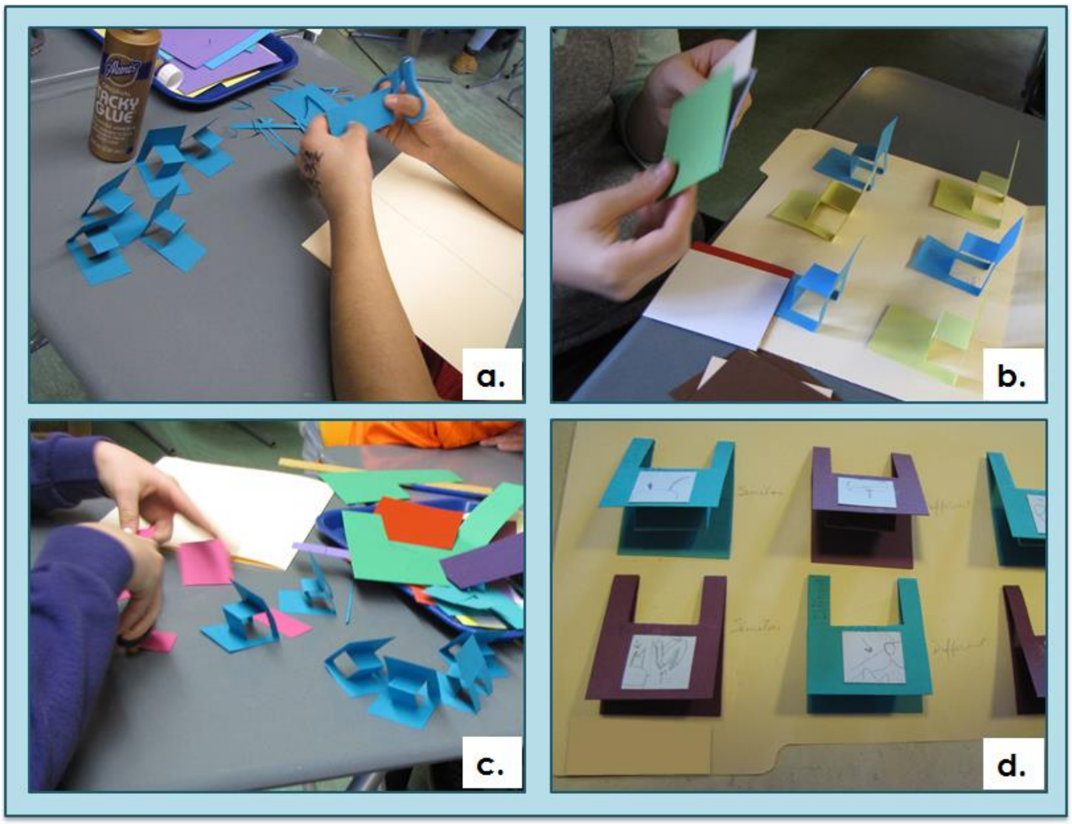

Figure 2. In the experimental condition, students cut (2a), fold and glue (2b, 2c) glue, and create illustrated pop-ups (2d) for the inside of their folders in the experimental condition.

Students Products

The majority of the students took great care in drawing their rainforest insects or marine organisms and in creating their pop-ups. They tried to make their drawings realistic and to clearly label the body forms. A few students struggled with the drawing because they thought their drawings had to be perfect, and with the limited time, they felt rushed. Some students expressed they were not skilled at drawing and therefore didn't put any extra effort or time into making their drawings better. A real surprise to the researcher was that some students struggled with the cutting and gluing of the pop-ups, as they were not used to craft work and lacked fine motor skills. Figure 3 is an example of one of the finished products, the entire pop-up folder.

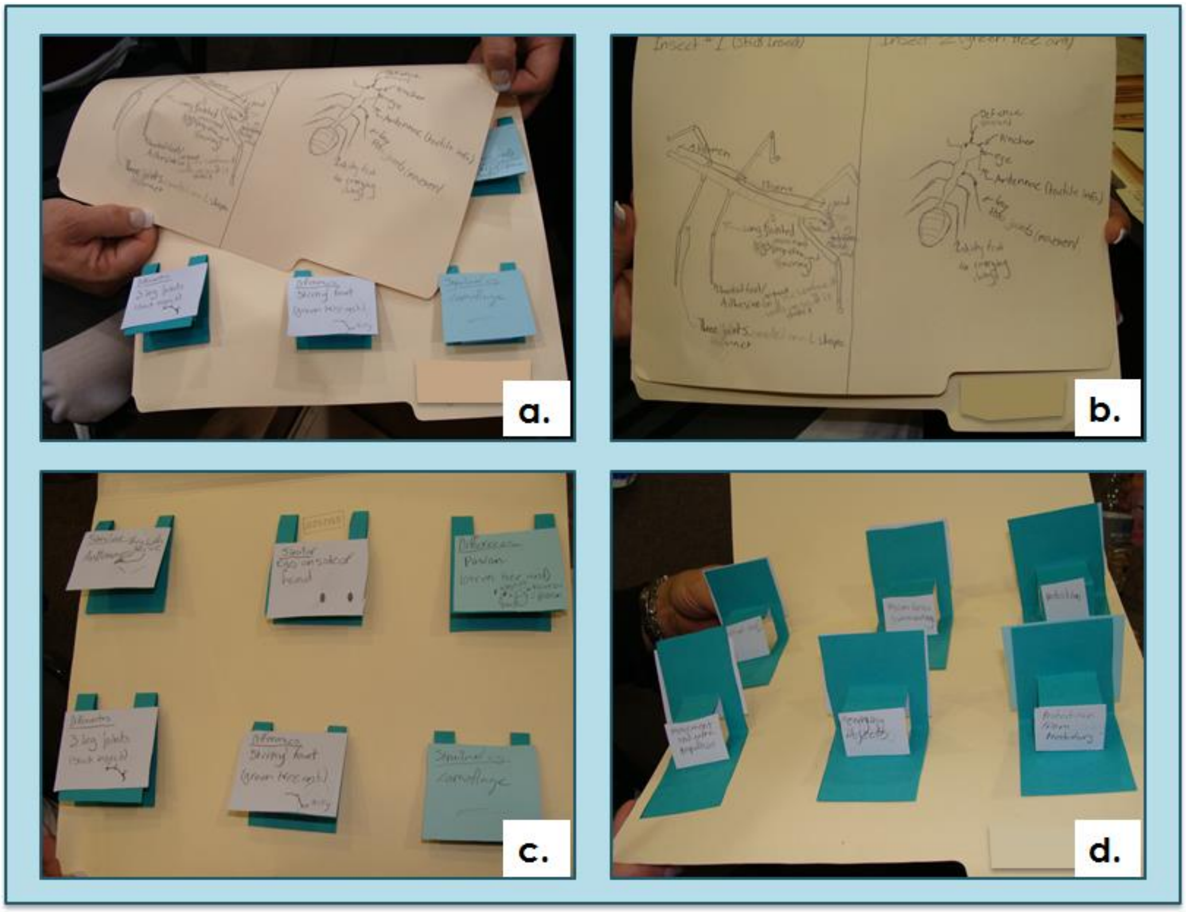

Figure 3. Example of a final product from the experimental condition. Figure 3a shows the folder held so the drawings on the front can be seen along with the pop-ups within the folder; 3b shows the drawings on the front of the folder; 3c shows the closed pop-ups with form drawings; and 3d shows the inside of the pop-ups where students identified the function of the form drawn on the top.

Pretest, Posttest, and Distal Posttest Results

Table 2 presents the pretest, posttest, and distal posttest results, showing student performance under the two conditions. A total of 128 students were enrolled in the 6 sections of the eighth grade science class; 91 students of the 93 who submitted consent forms from those 6 sections participated in at least one of the assessments. The final data set consisted of only those students who participated fully in all three of the assessments: the pretest, posttest, and distal posttest. Students who did not participate in any of the three assessments or who only partially completed one or more of the assessments were removed from the data set. Students who did not provide signed student and parent consent were also excluded from the data set. Many students missed classes and these lessons for a variety of reasons including being held in other classes to complete work, absences because of illness or family events, and relocation to another school. The final sample population for the testing assessment consisted of only 32 students who provided signed consent forms and participated fully in the lessons along with all three assessments.

On the pretest there were no significant differences in student prior knowledge of the topics addressed by the experimental and control conditions. At the time of the posttest, students performed better in material addressed during experimental conditions with a medium effect size. The pretest to posttest gain scores showed that students had higher scores for the experimental condition, but there was too much variation in scores for it to be statistically significant. By the time of the distal posttest (one month after the posttest), the effect size between the experimental and control conditions was large. Finally, the pretest to distal posttest gain scores showed a medium effect favoring the experimental condition.

Table 2. *Pretest, Posttest, and Distal Posttest Results (n=32)**

Timing	Mean Scores		Paired *t*-Test *p*-Value	Significant Difference?	Cohen's *d*	Effect Size Interpretation
	Experimental Condition	Control Condition				
Pretest	1.31 (3.1)	0.75 (2.0)	0.21	No	-	-
Posttest	8.44 (4.3)	6.41 (3.6)	0.02	Yes	0.51	medium
Pretest to Posttest Gain Score	7.13 (5.3)	5.66 (3.3)	0.10	No	-	-
Distal Posttest	8.59 (4.6)	5.34 (3.5)	0.002	Yes	0.80	large
Pretest to Distal Posttest Gain Score	7.28 (4.8)	4.59 (4.0)	0.01	Yes	0.61	medium

* Standard deviations in parentheses

Survey Rating Results

Students completed a survey measuring enjoyment, motivation, and perceived learning about the two lessons in which they participated under different conditions. As stated earlier, all 93 of the 128 students enrolled in the science classes, completed this survey; therefore, to be clear and show both levels of participation, survey data are included in two ways: 1) for all 93 students who completed the survey (Table 3) and 2) limited to the same 32 students reported for the content data (Table 4).

Surveys from 93 of the 128 students enrolled in the eighth grade science classes were included in the data shown in Table 3. There was a significant difference favoring the experimental condition in all measures except motivation but including the mean of all three scores. These differences each had a small effect size.

Table 3 *Student Mean Attitude Scores for Enjoyment, Motivation, and Perceived Learning* (n=93)

Measure	Mean Score		Paired *t*-Test *p*-Value	Significant Difference?	Cohen's *d*	Effect Size Interpretation
	Experimental Condition	Control Condition				
Enjoyment Rating	5.85 (2.7)	4.99 (2.7)	<0.001	Yes	0.32	Small
Motivation Rating	5.90 (2.6)	5.74 (2.8)	0.30	No	-	-
Perceived Learning Rating	7.03 (2.4)	6.38 (2.8)	0.008	Yes	0.25	Small
Mean of Three Ratings	6.26 (2.1)	5.72 (2.4)	0.005	Yes	0.24	Small

Surveys from 32 of the 128 students enrolled in the eighth grade science classes, the same students who completed all three of the testing assessments, were included in the data shown in Table 4. There was a difference favoring the experimental condition, but it was not significant.

Table 4. *Student Mean Attitude Scores for Enjoyment, Motivation, and Perceived Learning* (n=32)

Measure	Mean Score		Paired *t*-Test *p*-Value	Significant Difference?	Cohen's *d*	Effect Size Interpretation
	Experimental Condition	Control Condition				
Enjoyment Rating	5.56 (2.7)	5.03 (2.6)	0.13	No	-	-
Motivation Rating	5.53 (2.7)	5.88 (2.7)	0.25	No	-	-
Perceived Learning Rating	6.94 (2.5)	6.59 (2.7)	0.16	No	-	-
Mean of Three Ratings	6.01(2.2)	5.83 (2.4)	0.31	No	-	-

Student Reasons for Enjoyment, Motivation, Perceived Learning Survey Ratings

Enjoyment. Table 5 shows student reasons for their enjoyment of the lesson activities under the two conditions. Students gave far more positive comments for the experimental condition than the control condition and more negative comments for the control condition. This finding supports the numerical ratings finding for enjoyment. Besides remarking that the treatment condition was "fun," students expressed that the craftwork was their reason for enjoyment of the activity. Although students found both conditions to be "hard or difficult," students in the control condition identified the activity as "boring."

Table 5. *Student Reasons Given for their Enjoyment Ratings for the Experimental and Control Activities*

Reasons Given by Students for Enjoyment Ratings	Frequency	
	Experimental Condition	Control Condition
Fun:	25	17
I liked the craft work	19	0
It was okay	14	13
Enjoyed learning	9	4
Liked the topic	9	0
Interesting	3	8
Liked computer work	0	5
Total Positive Comments	79	47
It was hard or difficult	15	10
It was boring, not fun, not exciting, or took forever	13	23
Did not like the topic	5	12
Disliked the art work	5	0
Confusing	4	10
Time pressure	3	3
Hard to find information	0	9
Disliked computer work	0	4
Total Negative Comments	45	71

Motivation. Table 6 shows the reasons students gave for their ratings in motivation. Of the three attitude areas, the explanations for motivation were the most diverse. This diversity of reasons made it much more difficult to narrow the responses to common themes. This could be the reason for the divergence in the quantitative results for motivation. In addition to the difficulty in narrowing the responses to common themes, it was also more difficult to determine positive responses from negative responses as they were not as clearly value laden as in the enjoyment attitude area. For example, some students focused on the completion of the activity, but their wording implied either a sense of accomplishment at finishing the project or a sense of completion because the assignment was required. While both addressed the aspect of finishing the project, the researcher determined the accomplishment comments to be positive and the required work comments to be negative given the tone of the responses. Another example that was ambiguous was about the grade being important. While good grades could be a positive comment for some, these responses in this motivation survey implied that the grade was the reason for motivation as opposed to a preference for the topic or activity; therefore, the researcher determined this comment to be a negative response. Even allowing for the variance, the results confirm that the students showed higher motivation for the treatment than for the control.

Table 6. *Student Reasons Given for their Motivation Ratings for the Experiment and Control Activities*

Reasons Given by Students for Motivation Ratings	Frequency	
	Experimental Condition	Control Condition
Liked the craft activity	16	0
It was okay	16	12
Interested in topic	9	3
Fun	5	5
Accomplishment	4	12
Positive Attitude	2	5
Appreciated help	2	2
It was easy	2	2
Liked chart activity	0	4
Learned something new	0	3
Glad to find information	0	1
Total Positive Comments	79	47
It was required	12	9
Not exciting or fun	9	14
Too much work	8	0
Did not like craft activity	5	0
Good grade is important	4	9
Confusing	4	7
Hard to find information	3	4
Doesn't like schoolwork	3	2
Not interested in topic	2	10
Ready for spring break	1	2
Time pressure	1	0
Tired	1	1
Not interested in chart activity	0	7
Doesn't like homework	0	3
Bad at research (self-perception)	0	1
Distracted	0	1
Hard or difficult	0	1
I don't care	0	1
Total Negative Comments	45	71

Perceived learning. Table 7 provides the students' reasons for their ratings of their perceptions of learning for each of the lessons. The ratings, as shown in Tables 3 and 4, indicated that students perceived learning more under the experimental condition, and this is supported by the qualitative data if focusing on the specific content of learning. Students perceived more learning in the control condition when focusing on the general content of information learned. An aspect that could have skewed this data was the number of students whose comments were off topic from perceived learning. A large number of the students made comments that had no connection with the perception of learning.

Table 7. *Student Reasons Given for their Ratings of Perceived Learning for the Experimental and Control Activities*

Reasons Given by Students for Perceived Learning Ratings	Frequency Experimental Condition	Control Condition
A lot about forms and functions	11	5
A lot about similarities and differences	9	6
Total Positive Comments (Specific Content)	20	11
A lot about the topic	29	38
New things	1	1
Quite a bit	3	5
Some stuff	13	12
A few things	6	5
Total Positive Comments (General Content)	52	61
Didn't learn much	6	10
Total Negative Comments	6	10
Off topic comments: I don't like to look/feel/read/talk about bugs, I paid attention, I hate homework, It just is, Hmmmm because, No comment, etc.	35	29

Discussion

The results of this study showed that the integration of art into eighth grade science classes produced positive overall enjoyment, motivation, and perceived learning in students and better performance on the posttest and distal posttest. These positive results for arts integration in science are supported in the study by Rinne, Yarmolinskaya, and Hardiman (2011). Students did not have much information about the science content when beginning this unit, so conditions, control and experimental, supported learning. The experimental condition, however, was more beneficial for the students as it allowed students to have some personal choice and integrated creativity, similar to Land (2013).

Teacher and Researcher Observations

During the student work time, a variety of observations were made by the researcher and teacher. Some of the students were conscious of their inability to draw and needed encouragement to continue. Other students were perfectionists with their drawings and struggled with the time allowed because they wanted to keep adding details. Some students were engrossed in reading their researched information and didn't want to do any recording, drawing, or identifying. Others struggled with finding the exact information they wanted. Some students struggled with using scissors to cut and also with gluing the cardstock into place. These observations support Land's (2013) comments about the need for more creativity in schools to develop student skills in creative work and imagination.

Quite a few of the students engaged in conversations with their peers about the different forms and functions. Students engaged in conversations about marine organisms having feet and other human-like forms, about rings on shells marking years like rings on trees, about organisms actually living and growing inside of shells, among other insights. Students were surprised by many of the discoveries they made. This observation supports the work of Bequette and Bequette (2012) who reported that students benefit from the blending of arts and science because it helps them broaden their views so they are able to see ideas in more than one way.

The student products showed great variety as well an example of divergent thinking supported by arts integration (Bequette & Bequette, 2012). There was much freedom for the students in choosing their insects and organisms, the forms and functions to identify, the colors of their cardstock, and how they cut, glued, and created their popup folders. This led to different styles and structures of popups. Some students chose to make their form identifiers larger, while others chose to make the descriptions larger. Some chose to draw the insects and organisms to fill the paper, while others chose to draw them in a smaller scale. The perspective angle of the animal drawings also varied among the students even though most student drawings were made from photos they found online. Activities like these support the development of foundational spatial thinking skills, which are very important to the understanding of STEM concepts and choice of STEM careers (Uttal & Cohen, 2012).

Better Learning and Retention of Content

Calculations showed that the distal posttest effect size was large. This supports the study conducted by Rinne, Yarmolinskaya, and Hardiman (2011). Their results also showed a greater effect size with the distal posttest than with the immediate posttest. These results show that students retained information they learned in the arts-integrated lessons better in the long run than information acquired in the control condition. The effects of intently examining specimens or photographs and sketching their features allowed students to remember the information better.

During researcher observations of students working, student interest in the organism body part research was primarily positive. Most of the students shared details and information with other students nearby. They were talking about the forms and functions of the animals as they discovered information they did not know prior to this research such as internal organs that humans also have and similar body appendages.

Enjoyment, Motivation, Perceived Learning Ratings

Enjoyment. Students evidenced increased enjoyment during the arts integrated experimental condition activities. Students were having fun doing their drawings to reflect the information they has researched. This supports the study conducted by Nevanen, Juvonen, and Ruismaki (2014), which showed that integrating the arts into curricular classes increased the joy students felt when learning something new.

Motivation. Determining the incentive for motivation in middle school students through observation is not an easy task. A variety of levels of motivation were observed daily in all of the classes. The results of the motivation –related items of the attitude survey clearly showed higher ratings when students were in the treatment conditions. The comments showed that the students had a wide variety of rationales for their motivation or lack of motivation.

Perceived learning. The students' perceptions of their own learning were positive in both control and experimental conditions, supporting learning under both conditions. The marked difference was in the specific knowledge of organism body parts. The effect of the experimental condition on specific knowledge of similarities and differences concerning form and function, two of the primary goals of the lesson, was much higher than in the control condition. This was shown in both the immediate posttest and distal posttest as they did do better on both.

Conclusion

The findings of this study indicate that art-integrated lessons have a positive effect on student learning and student attitudes. Students in this study used art (sketching and pop-up constructions) to compare and contrast either two modern insects or modern and fossil marine organisms. Pretest, posttest, and distal posttest results showed a positive effect on student learning. Students learned the material better and retained it longer because they examined the photographs or specimens more closely to sketch them, thereby practicing the content information. Using a scale measuring enjoyment, motivation, and perceptions of learning, results showed a positive effect on students as well.

Implications for Classroom Practice

Although many classroom teachers think including art takes more time, both experimental and control conditions took the same amount of time, and students noted that they wanted more time in both conditions. Preparation time for the teacher was definitely higher, and it is difficult for teachers to predict outcomes when trying new approaches. To allow teachers to feel more comfortable, professional development programs on the integration of the arts into lesson activities would be important. Teachers need to have the confidence to support the more relaxed environment that crafting requires.

Suggestions for Future Work

There were three limitations to this study. The data definitely show that the integration of art had a positive effect on these students in these science classes in this school, but this does not mean that it is generalizable to different populations in different schools. More studies should be conducted to see if the findings are similar in other districts and in other disciplines. The second limitation was that this study focused on one area of arts integration, that of drawing and making a simple pop-up construction. There are a variety of ways to integrate the arts into core subject areas, and more studies are needed to explore the different techniques of art integration. The third limitation was the amount of student data excluded because of lack of completion. If the study could have been extended, more of the testing assessments might have been completed.

Acknowledgements

This material is based upon work supported by NASA under Grant No. NNX15AJ16H. A grant from the Iowa Biotechnology Association also supported this work.

The first author of this paper is a doctoral student who was enrolled in a seminar course titled *STEAM: Arts integration into the Science, Technology, Engineering, and Mathematics K-8 Curriculum: Writing Articles for Peer-Reviewed Journals*. The second author is a classroom teacher who was enrolled in a workshop titled *From STEM to STEAM*. The doctoral student and the teacher collaborated under the guidance of the course and workshop instructors, Dr. Audrey Rule and Dr. Dana Atwood-Blaine, respectively. The authors of this paper acknowledge the design and editing assistance of Dr. Audrey Rule during the development of this paper.

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