Third Graders Explore Sound Concepts through Online Research Compared to Making Musical Instruments

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Abstract

This study is an exploration of several lessons on sound taught to third grade students using one of the Next Generation Science Standards (3-5-ETS1) and arts integration. A counterbalanced, pretest- posttest- distal posttest design experiment was conducted to compare student knowledge and attitudes between the control and experimental conditions. Control activities included learning about either stringed or percussion instruments (whichever not addressed in the experimental condition) through online searches for information and writing a factual paragraph; experimental activities included creating a percussion or stringed instrument using classroom art materials purchased with an imaginary budget. One group experienced the experimental condition focusing on stringed instruments while the experimental condition for the other group focused on percussion. Results indicated no significant differences on the posttest, distal posttest, or gain scores. Scoring of lesson products (control condition paragraphs compared to experimental condition student-made instruments) indicated a significant difference favoring the experimental condition with a medium effect size. Student attitudes at the time of the distal posttest indicated a significant difference in enjoyment favoring the experimental condition with a medium effect size; there was no significant difference in student attitudes of perceived learning. Although learning occurred in both conditions, students reported the more rewarding experience involved creating the sound making instruments.

Key Words

Arts-integration, shadow puppets, science methods, preservice teachers, minority scientists, culture, STEM education, STEAM education

Introduction

Although the concepts of STEM (Science Technology Engineering Mathematics) education have been discussed for some time, the idea of STEAM (Science Technology Engineering Arts Mathematics) education is fairly new to the conversation. Arts integration into science, technology, engineering, and mathematics is creating a new mode of teaching that is significant to the learning process and to increasing learning of the concepts necessary for the future of a population in need of increased STEM skills.

Literature Review

From STEM to STEAM

The late 1990's provided educators with a new phenomenon in education identified as STEM or science, technology, engineering, and mathematics. A term coined by Dr. Judith Ramaley of the National Science Foundation, STEM was recognized as a form of educational inquiry in which students were required to solve real world issues. STEM was seen as a way of requiring students to be innovative in the creation of something of use (Daugherty, 2013). The substantial concepts of STEM education include: play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation networking, negotiation, and visualization (Sutherlin & Jennings, 2015).

Recognized as a significant proponent of the current initiatives in the American educational sphere, the STEM movement is growing rapidly. Teaching and learning in these subjects are necessary to provide our population with the important skills to stimulate growth in technology and scientific advancement (Bailey, 2016; Daugherty, 2013). Even President Obama recently stated “science holds the key to our survival as a planet and our security and prosperity as a nation” (Land, 2013, p. 547).

A more recent addition to the world of STEM is STEAM. This acronym represents the modern STEM educational approach combined with arts integration (represented by the “A”). Recently, the Makerspace movement (Kurti, Kurti, & Fleming, 2014) has advocated for students learning concepts through hands-on construction and building in an environment of curiosity, wonder, playfulness, and collaboration. Arts integration into STEM through the making of concept-related arts, crafts, or constructions enhances a student’s experience with the individual or collective subjects and improves students’ aesthetics and visual learning (Froschauer, 2015; Robelen, 2011). Art, which has long been considered a luxury in many schools and a subject often thought to be available only to the elite, is finding its way back into the school environment as an essential way of learning and of utilizing STEM concepts. This reintegration of art into the classroom was stimulated by teachers who were finding it difficult to teach STEM concepts independently of the art components (Bequette & Bequette, 2015). Art allows STEM projects to be developed through a plan.

The creative process in STEAM is highly stimulating for students. The integration of art forces the student to research the STEM need, select a STEM solution, and then create the solution incorporating both STEM and art, generating even more significant stimulation in the creative learning process. Bailey (2016) believed that having artistic intuition in creation in STEM, equally represented by both technology and art, would be most effective in producing extraordinary products.

Theoretical Framework

Drawing from multiple disciplines, the movement of STEM education with arts integration as STEAM, is the theoretical framework which shapes this study. Combining these multiple research communities allows for a unique learning experience and a distinct way in which education can be explored (Henderson, Beach, & Finkelstein, 2011). Although STEM, as a framework, has been utilized for some time, the addition of art integration is a more recent addition producing STEAM educational research.

Creativity

The definition of creativity, most especially in how we apply the concept of originality as a part of STEAM, is challenged by previous assumptions or misconceptions (Runco & Jaeger, 2012). The way in which one defines creativity affects the phenomenon or unique results that may occur from a STEAM project (Bailey, 2016). Producing a STEAM product that is extraordinary may be moderated by the maker’s comfort level, sometimes allowing an individual to be both different and unique. Bullying and victimization in the classroom (Juvonen & Graham, 2014) manifest an environment in which young people are driven to assimilate. This motivation to conform is a way of avoiding being different, perfect fuel for victimization. This need to adapt makes it difficult for young people to allow themselves to be unique, different, or even extraordinary. Bailey (2016), however, was confident that students would overcome this fear of being different through experience and education, stimulating significant STEAM products. Such education may even lead to a greater acceptance of diversity or difference in the classroom setting, benefitting overall learning.

Creativity has been defined most commonly by a recent and broadly accepted definition of originality and value to society. Runco and Jaeger (2012) recognized that the meaning of creativity has a much deeper and richer history that is relevant to the conversation surrounding the word's definition. Words such as variation, uncommonness, adaptability, effectiveness, usefulness, have been included in the conversation about creativity, but what is often lacking is addressing who may be deciphering or accepting the actual definition. This audience may affect the perceptions of STEAM products.

Integration of STEM into Art

A unique approach to STEAM recently explored was the implementation of STEM into art and art education. This unusual approach benefits a student's art and that student's conception of creativity related to cultivation of an integrated holistic effort in the STEAM process (Barrett, Webster, Anthila, & Haseman, 2015). Essentially this is the construction of an art project using the components of STEM rather than creating a STEM product by using art. Although there are other significant components that are held in common between these subject areas, the design and creation processes are most significant. The challenge that has been reported as most difficult to overcome was the fact that art typically is perceived as an individualistic opportunity to shine and in these collaborative efforts between artists and STEM professionals, teamwork must be emphasized.

The Benefit of Longterm Retention of Content

A recognized benefit of STEAM is the increase in longterm retention of content among participating students. The longterm retention mechanisms supported by integration of arts include: rehearsal, elaboration, generation, enactment, oral production, effort after meaning, emotional arousal, and pictorial representation (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011).

Hardiman, Rinne, and Yarmolinskaya, (2014) conducted a study with fifth graders comparing a typical science curriculum to very similar science activities that were arts-integrated, finding that longterm learning of science content was enhanced by the arts. There are nine mechanisms for art integration that were used in this study and provided greater learning retention (Rinne et al. 2011). These arts mechanisms operate through repetition of content, making personal connections to content, thinking about its meaning, adding details, and making examples unusual, thereby making it more memorable.

The foregoing literature review has shown that several other studies found arts integration to be significant to the STEM conversation (Bailey, 2016; Henderson et al., 2011) with long term retention benefits (Hardiman et al., 2014; Rinne et al. 2011). Unfortunately, there are only a few studies in the literature testing this idea. Therefore, the broad research question of this study is to determine if arts integration improves STEM learning and retention of information. The study addresses the following research questions:

- Do students learn more, less, or similarly when researching and writing about instruments compared to crafting one?
- What are students' attitudes pertaining to researching and writing about instruments and crafting them?
- Is there greater, less, or similar longterm retention of information when facts about instruments are researched and a factual paragraph written compared to crafting instruments that display required features?

Methods

National Science Standards

The next generation science standard that will be utilized for the current study is 3-5-ETS1 Engineering Design. In 3-5-ETS1-1, students are asked to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. In this study, students were limited by all three constraints as they created a musical instrument during a specified class period from new and recycled classroom craft materials using a budget. Important to the evaluation of STEAM products is deconstruction, examination, interpretation, and implementation of the Next Generation Science Standards and not simply describing the learning goals and how those particular goals are assessed (Workosky & Willard, 2015). In essence, being able to thoroughly understand the standard that is being set, the instructor must carefully explore the standard to construct a meaningful and successful learning experience for the student.

The only standard for sound provided by the next generation science standards, unfortunately, is the 1-PS4 Waves and their Application in Technologies for Information Transfer. The PS4.A Wave Properties include the concept that sound can make matter vibrate, and vibrating matter can make sound (1-PS4-1). This standard was loosely utilized in the current study, but was not necessarily significant because the standard was for first grade students rather than third graders.

In addition to the science standards for this art integration STEM project, the visual arts standards Cr1.1.3a "elaborate on an imaginative idea" and Cr1.2.3a "apply knowledge of available resources, tools, and technologies to investigate personal ideas through the art-making process" were utilized. Both followed the specifications of the National Coalition of Core Arts Standards (2014) and are significant to the creation of both a visually appealing and sound-producing instrument. The expectation for third graders was to create a visual arts project using the investigate-plan-make concept. Part one of the art standard used for the participating 3rd graders encouraged them to elaborate on their imaginative idea while creating a stringed (Group A) or percussion (Group B) instrument. Part two of the standard, apply knowledge of available resources, tools, and technologies in order to investigate their own personal idea through the art-making process was also used in the construction of the instruments.

Subjects

Twenty-one third grade students (13 female, 8 male; 19 European American, 1 Middle-Eastern American, and 1 Asian American) were participants. This study was approved by the Internal Review Board Human Subjects Committee of the overseeing university, the assistant superintendent of the school district, and the school building principal of the classroom in which the study took place. All 21 students and their parents were fully informed and provided signed consent.

Design

This study was a mixed-methods, pretest-posttest-distal posttest counterbalanced design (Fraenkel & Wallen, 2003). Counterbalanced design was most useful in this process because all of the students participated in both the control and the experimental conditions, but not at the same time. The convenience sample used for this study was a third grade class divided into two random groups: Group A and Group B. Both groups took an identical pretest that focused on concepts about sound of both stringed and percussion instruments. The participants were given a general introductory lesson about sound, for Lesson 1. During Lesson 2, Group A made a stringed instrument, while group B researched and developed a paragraph about stringed instruments. Group B then created a percussion instrument while Group A researched and wrote a paragraph about percussion instruments. Both groups presented their instruments and the paragraphs they researched. Group A and Group B took the identical posttest and took a distal posttest 3 weeks after the lessons had been completed. An attitude assessment was also administered pretest, posttest, and distally.

Pretest, Posttest, and Distal Posttest

There were ten questions on the identical pretest, posttest, and distal posttest. Five of the questions addressed content specific to stringed instruments and five focused on percussion instruments. Both conditions were designed so that students would be able to learn the information addressed by this assessment through completion of the activities. In the experimental condition, students were to think not just about the way in which the instruments were created, but the different parts that an instrument contains and how that affects sound, volume, or pitch. Table 1 shows the items that appeared on the pretest, posttest, and distal posttest. The bolded and underlined responses are the correct responses.

Table 1. *Questions on Pretest, Posttest and Distal Posttest (Correct Answers Underlined)*

1. What amplifies sound (makes it louder) for a stringed instrument?
a. The length of the strings
b. The bridge
c. The way the instrument is held or moved while being played
d. The sound box
e. The instrument's voice
f. I really don't know.

2. There are three ways that strings can produce different high or low notes:
a. Sound, pitch, volume
b. Length, weight, tightness
c. Height, weight, volume
d. Mass, capacity, depth
e. Pressure, volume, mass
f. I really don't know.

3. In a stringed instrument, what does the bridge do?
a. The bridge supports the strings and transfers vibration
b. The bridge holds the bow together
c. The bridge is used to adjust the tightness of the strings
d. All of the above.
e. The bridge connects the long part of the instrument to the big bowl-like part.
f. I really don't know.

4. Thicker strings make deeper-pitched sounds because:
a. They have less mass or weight
b. They are tighter
c. They vibrate slower
d. They have various pitches
e. All of the above.
f. I really don't know.

5. If a string is tight, it will produce a note that is
a. Clearer
b. Scratchier
c. Lower
d. Higher
e. Quieter
f. I really don't know.

6. A percussion instrument produces sound when it is
a. Strummed, bowed, or plucked
b. Hit, shaken, or scraped
c. Blown, whistled, or muffled
d. Air-filled, rubbed, or blocked
e. None of the above
f. I really don't know.

7. Bells have a low pitch when they are
a. Large
b. Small
c. Made of metal
d. Made of ceramic (pottery)
e. Bells don't have a low pitch
f. I really don't know.

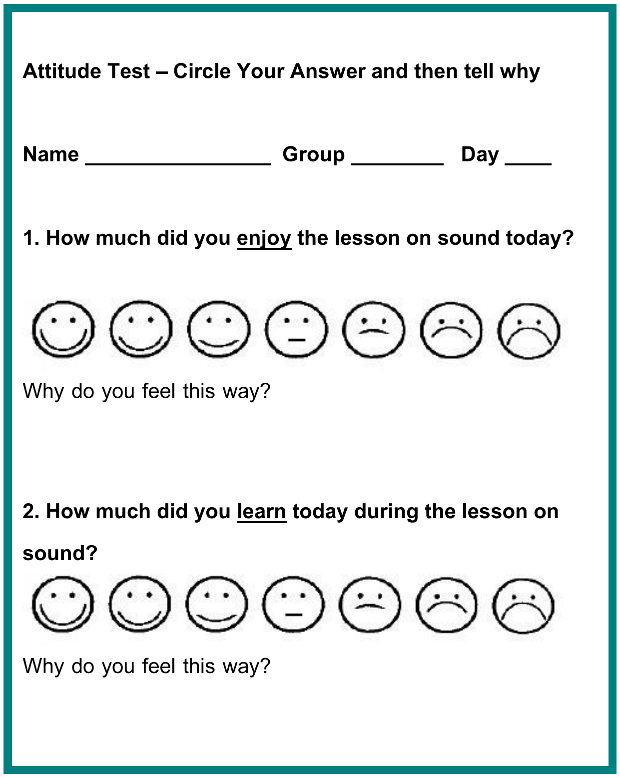
8. Increasing pressure to a percussion instrument creates higher
a. Pitch
b. Tone
c. Volume
d. Beats
e. Melody
f. I really don't know.

9. What are percussion instruments used for in music?
a. Special effects and mood
b. To keep the rhythm
c. Both of these
d. None of these
e. I really don't know

10. Which set contains ***all*** percussion instruments?
a. Sandpaper blocks, rattle, and chimes
b. Xylophone, tuba, and piano
c. Cymbals, drums, and flute
d. All of the above
e. None of the above
f. I really don't know

Attitude Survey

The attitude survey was administered after every lesson and used to determine enjoyment of the activities and student perception of learning during each activity. See Figure 1.



Attitude Test – Circle Your Answer and then tell why

Name ________________ Group ________ Day ____

1. How much did you enjoy the lesson on sound today?

Why do you feel this way?

2. How much did you learn today during the lesson on sound?

Why do you feel this way?

Figure 1. Attitude Survey

Lesson Procedures

A constructivist approach to lesson planning, the 5E instructional model of engagement, exploration, explanation, expansion, and evaluation (Trowbridge & Bybee, 1990), was used.

In the Engagement Phase, the teacher showed a musical wind instrument made from recycled and craft materials and explained to students that they would have the opportunity to create a musical instrument in this unit. This visual gained student attention and focused students on the topic.

For 10 minutes, During the Exploration Phase, the teacher discussed with students, “What do you know about sound and musical instruments?” During this Exploration Phase, the teacher determined students’ prior knowledge and mentally prepared them to learn more because they had examined their knowledge and were curious about the lesson topic.

The Explanation Phase included a 20-minute lesson in which students examined photographs of instruments, some real instruments, and small musical video clips introducing them to concepts of sound, pitch, tone, and volume. The teacher showed a slide presentation that contained photographs, musical clips, and concepts of sound. The teacher then read them a book about sound and musical instruments. There were 10 minutes allotted for a discussion about the instruments and sounds they had observed.

During the Expansion Phase, students were given the opportunity to look at the items that they could purchase with an imaginary budget of five dollars to create their instruments. They were then given a piece of paper and asked to sketch out an idea for an instrument they would like to create. They were provided a card on which to record their expenditures in purchasing materials to create the instrument they were visualizing. After purchasing the items, they created either a percussion or stringed instrument that was designated by group.

Group A students first researched and wrote a paragraph about percussion instruments, then later, each created a stringed instrument. Group B students began by each creating a percussion instrument and later researched and wrote a paragraph about stringed instruments. During the fourth lesson period, Group A students had 15 minutes to create a poster that listed at least 5 bulleted points about percussion instruments, while Group B students took fifteen minutes to examine and practice playing their homemade percussion instruments. Later in that same lesson, Group B had 15 minutes to create a poster which contained at least five bulleted points about percussion instruments, while Group A examined and practiced playing their percussion instruments.

Later in the same lesson, all students, in turn, briefly presented their bulleted poster about stringed or percussion instruments. Then, students presented their crafted instruments, demonstrating their use, discussing the process used to create it, telling the different parts of the instrument, and playing a few notes. This completed the expansion phase.

In the evaluation phase, a summative assessment of the students' two projects was recorded by the researcher using the rubric shown in Table 2 to score instruments and the analogous rubric in Table 3 to score paragraphs.

Table 2. *Rubric for Evaluating Handmade Instrument in Experimental Condition*

Criteria	Yes = 4	Mostly = 3	Somewhat = 2	A Little= 1	No = 0
Design. Does the instrument produce sound through its strings or through percussion?					
Design. If it is a stringed instrument, does it have a bridge, soundboard, and soundbox? If it is a percussion instrument, does it have a way to make low, medium and high pitches?					
Design. Is the instrument visually appealing in shape and decoration?					
Pitch. Is the student able to demonstrate at least three pitches: low to high with the instrument?					
Volume: Can the student explain whether the volume of the instrument is a louder or softer volume than other instruments?					
Budget. Did the student adhere to the budget?					
Creativity. Was the instrument unusual or original and thought of by the student rather than a copy of one someone else has done?					
Creativity. Does the instrument show elaboration and detail?					
Performance of Tune. Can the student play a repeating tune of 5 notes on the instrument?					
Total Score					

Materials for Making Musical Instruments

A variety of materials was available for students to create their musical instruments. The following recycled materials were provided to students for purchase to make musical instruments: tissue boxes, shoe boxes, cereal boxes, paper towel rolls, cardboard tubes, steel cans, and recycled butter tubs with lids. Many new items were available including rubber bands (various widths), wooden rods, small paper clasps, balloons, rice, dry white beans, small elbow pasta, number three pencils, and colored cotton balls. Students could also choose from the following art materials: sparkle and regular paint, wooden or metal beads, chenille sticks, precut letters, decorative magazine clips, plastic buttons, ribbon, crayons, markers, stickers, glue, duct tape, and clear tape. Equipment available to all students included a hole-punch and scissors.

Limitations

The knowledge and skills of the students in writing, research performance, fine motor skills, and familiarity with musical instruments varied greatly as acknowledged by the teacher. These data were not obtained for inclusion in the study and may have been insignificant to the results, however, we acknowledge that improvements could contribute to a future study.

Table 3. *Rubric for Scoring the Instrument Fact Paragraphs of the Control Condition*

Criteria	Yes = 4	Mostly = 3	Somewhat = 2	A Little= 1	No = 0
Content. Did the paragraph tell at least 5 facts about the type of instrument (stringed or percussion as assigned)? For stringed instruments be sure to explain bridge, soundboard, and soundbox. For percussion instruments, be sure to explain how low, medium, and high pitches can be made.					
Resources. Did the student record at least 2 different book titles or website titles from which information was taken?					
Organization. Did the paragraph have a topic sentence?					
Organization. Were all sentences related to the topic?					
Specific Instrument. Did the student choose a specific instrument of the assigned type and write about it?					
Content. Did the paragraph tell about tone, volume, and pitch of this instrument?					
Grammar. Was correct grammar used?					
Spelling. Was spelling correct?					
Interest. Was the paragraph interesting with new or exciting ideas?					
Total Score					

Results and Discussion

Table 4 shows the mean student scores on the multiple choice assessment. There were two parts included: one part with five questions focused on string instruments, and a second part, also consisting of five questions, pertaining to percussion instruments. Pretest, posttest, and gain scores were examined with paired t-tests conducted to compare each student's performance under both conditions. The pretest scores showed a significant difference between student performances on questions regarding musical content that would be encountered during the experimental condition versus the control condition. This may indicate that, although students were randomly assigned to groups, Group A seemed to have more prior knowledge about stringed instruments than Group B. Possibly, several students in Group A play stringed instruments at home or took private lessons.

There was no significant difference between the conditions on the posttest. Regarding the gain scores, a paired t-test was conducted that also showed no significant difference, indicating that the students who were at a disadvantage on the pretest caught up with their peers after the experimental condition. The scores on the distal posttest favored the experimental condition, however this difference was not statistically significant. The pretest to distal posttest gain scores were not significantly different between conditions. In the long run, students learned approximately the same amount of factual information under both conditions. Although there was a greater gain in scores for the experimental condition, this increase was not enough to be significant. This is likely because of the low number of students in the sample and the broad range of abilities in performance. A future study with a larger sample size may show significant differences on a multiple choice test.

Student work completed in the experimental condition showed gains from the Posttest to the Distal Posttest, but again due to a small sample size it was not enough of a difference to be statistically significant. There actually was an increase in knowledge which may have to do with the learning that occurred after the lessons were completed, knowledge that was individually sought out after the lessons were completed, or knowledge gained through mental reflections upon the lessons. This is all a part of long term cognitive retention, which was obtained through a STEAM focused lesson.

Although this experiment was designed for students to work individually, it was difficult for the children to not be collaborative with one another. Both the classroom teacher and the researcher had to discourage children from helping one another to measure individual results. This desire for collaboration is stimulated by art integration into STEM (Barrett, et al., 2015; Guyotte, Sochacka, Costantino, Kellam, & Walther, 2015).

Table 4. *Mean Pretest, Posttest and Gain Scores on the Multiple Choice Assessment**

Multiple Choice Assessment	Control Condition	Experimental Condition	*t*-Test *p*-Value	Significantly different?	Cohen's *d*	Interpretation of effect size
Pretest Mean Score	1.80 (1.4)	2.50 (1.2)	0.047	Yes, favoring experimental condition	0.54	medium
Posttest Mean Score	2.60 (1.3)	2.60 (1.0)	0.50	No	-	-
Mean Gain Score from Pretest to Posttest	0.80 (1.4)	0.10 (1.2)	0.06	No	-	-
Distal Posttest Mean Score	2.60 (1.4)	3.00 (1.0)	0.13	No	-	-
Mean Gain Score from Pretest to Distal Posttest	0.80 (1.4)	0.50 (1.4)	0.23	No	-	-

*Standard deviations shown in parentheses

Instrument and Instrument Fact Paragraph Scores

Table 5 shows that there was a significant difference between the scores of the paragraph creation and the instrument construction. This difference was likely a result of enthusiasm and engagement with the instrument construction project. Students demonstrated more creativity and attention to the requirements of the tasks when working in the experimental condition.

The science and art standards that were utilized, interpreted, demonstrated, and assessed for the participants, showed much higher rubric scores for the Experimental Condition over the Control Condition and even with the very small sample size it was enough to be significant. This indicates that students need more practice researching information and writing. The two conditions were allotted the same amount of time for each lesson to keep the experiment fair. However, taking more time to conduct more inquiry by asking interesting questions and conducting a rich investigation from multiple sources would have allowed students to create stronger writings.

The higher scores on the assessment of the Experimental Conditions for both Group A and Group B, also indicate that the students were being very creative. In fact, all of the students except one received a 4 out of 4 score on both Questions #7 and #8 of the rubric, demonstrating creativity in the Experimental Condition. Demonstrating creativity through this experiment is both a way of training these students to be unique in their ideas (Bailey, 2016; Runco & Jaeger, 2012) and not fearing their differences.

Table 5. *Mean Rubric Scores for Handmade Instruments Compared to Instrument Fact Paragraphs**

Control Condition Mean	Experimental Condition Mean	*t*-Test *p*-Value	Significantly different?	Cohen's *d*	Interpretation of effect size
28.67 (5.2)	31.14 (5.2)	0.002	Yes	0.47	Medium

*Standard deviations shown in parentheses

Student Factual Paragraphs from the Control Condition

Students were able to locate interesting information for their paragraphs about the assigned instrument types. Here is an example of a good paragraph:

> Do you know what a percussion instrument is? Well you have come to the right place! A percussion instrument is an instrument that needs to be struck, rubbed, scraped, or shaken. Some percussion instruments vibrate like the gong or the cymbal. The percussion family is the largest instrument family. Lots of the percussion instruments are drums. Did you know that percussion instruments have been used for thousands of years? Since the times of the ancient Egyptians! Now you know about percussion instruments!

This student has provided a paragraph that contained at least 5 facts about percussion instruments. The student used the two search engines available on an individual laptop computers. The paragraph was well organized and related to the topic. The student spoke about the drums, gongs, and the symbols, which are specific instruments. The spelling and grammar were very good and the paragraph was interesting. The paragraph, however, was not very inclusive of the concepts of sound, volume, and pitch required by the assignment.

Some students had difficulty with this assignment. Here is an example of a typical paragraph with errors:

> Some of the strig [sic] instruments Sound is changed by pressing down. The linght [sic] of the string changes the sound. The Zithers is [sic] either plucked or bowed. Lyres are plucked by the player.

This particular paragraph was not well organized and contained only four facts about instruments. The student did not use correct spelling or grammar and did not reference volume, although the writer did vaguely address tone and pitch. The paragraph was not very interesting because the writer did not make clear what was being discussed.

Figure 1 shows students working on their paragraph research. Although some students were engaged in the writing process as demonstrated in pictures 1a, 1b, and 1c, they were also easily distracted by their interest in the crafted projects being made by classmates in the other group, which is demonstrated in photo 1d.

Figure 1. Students working on their research and paragraphs

Student Instrument Products from the Experimental Condition

Students were very enthusiastic about making the instruments during the experimental condition. Figure 2 shows students demonstrating some of their musical instruments. In Figure 2a, the student is demonstrating sound on a crafted ukulele. Having used two wooden rods as bridges, the student demonstrated that the pitch was clearer than when the rods were removed. Figure 2b is a guitar which was decorated with brightly-colored cotton balls, ribbon, fringe, and pink sparkle paint; this instrument actually produced cool sounds. In Figure 2c, the student is demonstrating sound on a harp with the different widths of the rubber band strings creating various pitches and volumes. The instrument is not as colorful as some of the others instruments created because the construction required time-consuming fastening of all the many rubber bands used for strings. This student was extremely proud of her accomplishment and radiated that emotion during the demonstration. In Figure 2d, the student constructed a drum with a recycled peanut can, a cut balloon for the top skin, and two pencils for the drum sticks. The student found the eraser ends made the lowest tone on the instrument. A student not pictured, who also created a drum similar to this one, found that hitting the top skin, the side of the container, and the metal bottom of the container with just one eraser end of a pencil made three different tones and volumes.

Figure 2. Students demonstrating their crafted instruments

Figure 3 shows example percussion instruments made by students during the experimental condition. Figures 3b and 3d are both drums with pencils for drum sticks. The instrument in Figure 3a was constructed from a tin can with a cut balloon and Figure 3b was a plastic container with a lid. They were both beautifully constructed, although Figure 3b was much more colorful. In Figures 3a and 3c the instrument was a shaker. Both of the two unique containers were highly decorated and colorful. The inside of the instrument in Figure 3a was filled with rice and the instrument in Figure 3c was filled with large rigatoni noodles. Both students experimented with the amount of filler material used, creating different levels of pitch and volume. Figures 3e and 3f are different views of a bell that was created out of crafted materials. The student used a pipe cleaner to fasten both a wooden and metal bead inside the tin can. The different beads made different tones and the combination of the two increased the volume the instrument could obtain.

Figure 3. Percussion instruments made by students during the experimental condition.

The stringed instruments produced by the third graders provided unique and different sounds based on the thickness of the rubber bands they used, the tightness of the strings, the way the strings were fastened to the sound box, and use of the wooden rods as either a bridge or a tool to pluck the strings. In pictures 4c, 4e, and 4f, the wooden rods provided were used as a bridge to lift the strings away from the sound box, the students noted that this made a clearer pitch. Picture 4a used small clips to provide an individual bridge for each string rather than the rod. In picture 4d the strings were fastened with small clips on the edge, allowing the student to tighten and loosen the strings to produce different tones. The instrument in picture 4b, was played by plucking the instrument with the small rod, this produced a unique sound with a more uniform was of playing multiple strings one after the other. Although the sound on these stringed instruments was incredible to witness, they lacked some of the decorative designs that were very prominent in the percussion instrument examples. The reason they were less decorative was a result of the more time consuming work required in the fastening of all of the strings.

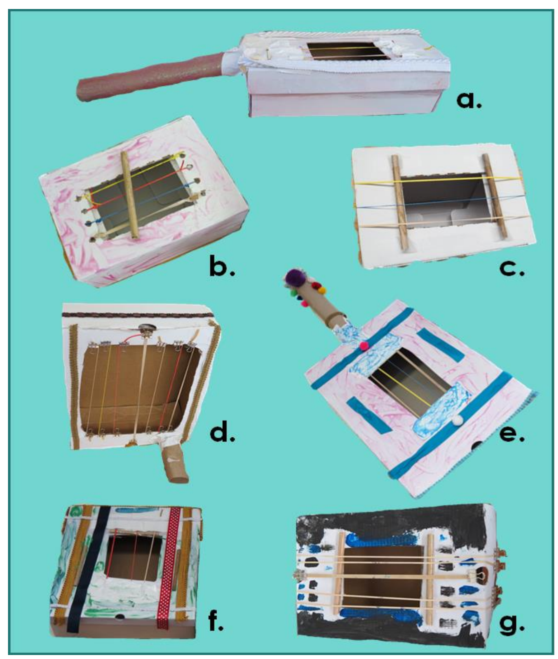


Figure 4. Stringed instruments made by students during the experimental condition.

Student Attitudes under the Two Conditions

Table 6 presents distal attitude survey data showing a significant difference in the student's attitudes about enjoyment of the assignments under the two conditions (instrument construction and paragraph creation) administered three weeks following the completion of the lessons. Cohen's *d* for this difference was 0.65, indicating a medium effect size favoring the experimental condition. Researcher observations of facial expressions and student comments during the lessons indicated that students clearly enjoyed crafting the instruments more than they did researching and writing the paragraphs. This impression was affirmed by the results of the distal attitude survey. However, the attitude survey results administered after the paragraph-writing and instrument-making lessons did not provide a significant difference. This discrepancy may have been caused by the fact that they were reflecting on each of the assignments individually at first, while the distal attitude assessment required them to reflect comparatively about the two projects.

Table 6. *Mean Attitude Scores for the Different Conditions**

Time	Attitude Rating Question	Control Condition Mean	Experimental Condition Mean	*t*-Test *p*-Value	Significantly different?
Combined data from each of two trials	How much did you enjoy the lesson on sound today?	6.9 (0.4)	6.7 (1.3)	0.32	No
	How much did you learn today during the lesson on sound?	6.7 (1.3)	6.6 (0.8)	0.35	No
At Distal Posttest	How much did you enjoy the lesson on sound?	6.2 (1.5)	6.9 (0.3)	0.02	Yes
	How much did you learn during the lesson on sound?	6.4 (1.4)	6.5 (1.2)	0.36	No

*Standard deviations shown in parentheses

Table 7 presents an analysis of reasons students gave for their attitude ratings. Mostly very positive about both lessons, students frequently noted they enjoyed making the instruments more than they commented they liked writing the paragraphs. From the attitude assessment given to the students in the study, the statement "I enjoyed learning about sound or instruments" was most frequent for the control condition. Even in the experimental condition, a few students stated they enjoyed learning about sound or instruments. In the experimental condition, students expressed that their enjoyment stemmed from actually being able to create the instruments: "I enjoyed making an instrument." Those that did not reference the specific creation of an instrument stated that they enjoyed the craft part of the project with decorating and being creative.

Table 7. Reasons Students Gave for Attitudes about Enjoyment of Lesson on Attitude Survey

	Frequency			
Reason Given for Enjoyment of Lesson	Control Condition		Experimental Condition	
	Combined data from each of two trials	At Distal Posttest	Combined data from each of two trials	At Distal Posttest
Like learning about sound or instruments	7	12	0	5
I like writing about instruments	5	0	0	0
Enjoyed research	4	1	0	0
Enjoyment of learning	3	0	0	2
I don't like music that much	1	0	0	0
I got to help my friend with her instrument	1	0	0	0
I enjoyed making an instrument	0	0	15	11
I love decorating and being creative	0	0	5	2
Because my instrument broke	0	0	1	0
I already know a lot	0	2	0	0
I got to know more information	0	4	0	1
I searched using a computer	0	1	0	0
Having a budget was fun	0	0	0	1

Conclusion

Summary of Findings

The findings in this study indicated that students who performed poorly on the pretest were able to match the scores of their peers on the posttest, after the experimental condition. Although the results indicated that the experimental condition provided somewhat better scores on the test, there were not enough participants to create a significant difference. On the initial attitude assessments, no significant difference was found between the control and experimental conditions after the lessons, but on the distal attitude assessment in which students reflected on the two activities, the students enjoyed the creation of the instruments more than writing the paragraphs. This study showed that students could attain the same level of learning concepts about sound and musical instruments through both a traditional online research and paragraph-writing approach and an arts-integrated instrument-making approach. Therefore, an arts-integrated approach is a viable alternative to traditional instruction and, because of its motivating effects on students, may even be favored.

Implications for Classroom Practice

This study shows significant implications for classroom practice in that the art activity may have been a way to teach students information that previously was not obtained, especially in comparison to those who had obtained the information through another avenue(such as private music lessons). Also, the pleasure that students took in learning this information through art was significant. The simple enjoyment implies that the student is more engaged and enthusiastic about the actual learning. Although students expressed enjoyment of using computers to research information about the instruments during the control condition, when comparing their recollections of the two conditions at the time of the distal posttest, students expressed more enjoyment occurred during the experimental condition.. As demonstrated in the photographs included in this study, the students displayed artistic creativity through the creation of the instruments (Bailey, 2016), which were both phenomenal and extraordinary.

Suggestions for Future Research

The current study could easily be repeated with a larger group, perhaps yielding more statistically significant results on posttest and distal posttest assessments. The new Next Generation Science Standards, previous to the current study, had not been implemented in the school. A comparison of current student performance to student performance after whole-scale implementation would be enlightening.

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