Exploring the Physics of Sound with STEAM-azing Third Graders

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Abstract

This practical article was based on a lesson conducted with third graders from an elementary school in the Midwest who were studying concepts about sound. The lesson activities address Next Generation Science Standards that include engineering concepts, along with integrating activities that support National Core Arts Standards. The students created instruments that made music but that were not the standard string, percussion or wind orchestral instruments that they had previously studied: string, percussion, or wind. Their instruments made of recycled materials included drum and shaker combinations, animal-shaped instruments, and instruments that combined three or more instruments.

Key Words

Arts integration, musical instruments, sound, elementary students.

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Introduction

Although the STEM (Science, Technology, Engineering, Mathematics) initiative in education has existed since the National Science Foundation joined science, technology, engineering, and math with the acronym "STEM," (Woodruff, 2013), a more recent approach is starting to take hold, STEAM (science, technology, engineering, ART, and mathematics). The importance of the initial STEM movement evolved from the need and desire of the United States to create economic growth, avenues for technological advancement, and to become more competitive in international markets (Guyotte et al., 2014; Sochacka et al., 2016; Bequette & Bequette, 2016). Not just the desire for growth stimulated the new incorporation of Art into the STEM conversation, but the realization that the collaboration of the multiple disciplines produced a greater, more useful product (Sochacka, 2016). The art integration concept is not necessarily new; rather, it dates to the time of the famous artist Leonardo da Vinci (Robelen, 2011). Leonardo Da Vinci was not only known as a painter and sculptor, but also as a "scientist, engineer, and inventor" (Robelen, 2011, p. 3; Sousa & Pilecki, 2013)

The movement in education under the No Child Left Behind Act resulted in art being abandoned from the

curriculum and an emphasis being placed on the highly tested subjects of mathematics and reading (e.g. Cawelti, 2006; Spohn, 2008). Because of the educational climate of high-stakes testing, decreases in federal, state, and local funding occurred that "have caused arts education to be marginalized or even eliminated from public school curricula" (May & Brenner, 2016, p. 223). Many students today even believe that art is a luxury item that will not be made available to them, making STEAM is an incredible opportunity to reincorporate art into the classroom curriculum.

The re-emergence of art as a priority in education is significant due to the positive effects art education has on the cognitive and social development of school age children. Critical thinking and the ability to express oneself through the imagination are "central to any definition of excellence in education" (Johnson, 2016, p. 66), which is the primary goal of current educational institutions. The conversation surrounding excellence in education is one that has continued since ancient Greece and has significantly influenced the commitment to art education as a part of common public schooling (Smith, 1987).

Standards Addressed by the Lesson

The incorporation of standards from different initiatives, such as art education, is meant to create interdisciplinary connections, enriching student learning (O'Hanley, 2015). The lesson described here was a STEAM lesson that supported the Next Generation Science Standards (NGSS; Achieve, 2013), National Core Art Standards (National Coalition for Core Arts Standards, 2014), the State Social Studies Standards (ICSS, 2017), the State Science Standards (ICS, 2017), and the Common Core Mathematics State Standards (CCSSI, 2018).

The NGSS standard ETS 1-1 asks students 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. When the students were introduced to their project they were told that this would need to be completed in two, 50-minute collaborative art times scheduled by the elementary art teacher and the classroom teacher. During this time, the students were also introduced to their five-dollar budget as well as the supplies and their costs. Another NGSS standard was also supported by this lesson was ETS 1-2: 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. The students planned their recycled-material sound machines or music makers and then explored the available materials. The students adapted their designs to fit their project budget and the evaluation criteria that were presented to them.

Several National Core Arts Standards were addressed by the lesson. VA: Cr1.1.3a: Elaborate on an imaginative idea. This standard was supported as students took an idea for a recycled sound machine and incorporated their knowledge of sound to create a new, one of a kind sound machine or music maker. Another standard, VA: Cr1.2.3a: Apply knowledge of available resources, tools, and technologies to investigate personal ideas through the art-making process, was addressed through the design and creation of their projects. This activity used previous investigations on the physics of sound that had taken place in the third-grade science setting. Additional standards addressed in this activity included the following: VA: Re9.1.3a: Evaluate an artwork based on given criteria occurred when students self-evaluated, and VA: Cn10.1.3a: Develop a work of art based on observations of surroundings. Each of these standards was applied in the learning process as students used their previous investigations on the physics of sound to create their own design of a recycled-material sound machine or music maker.

The State of Iowa Core Science Standards (2017) used in this activity were included in the Expansion Phase of the learning process. 3-5-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. This standard was supported by the idea that the children were to design a non-traditional instrument with a budget, with recycled materials, and during a few lessons. The standard, 3-5-ETS1-2: Generate and compare multiple solutions to a problem based on how well each is likely to meet criteria and constraints of the problem. When the students used the scoring rubric to determine if their instrument met the criteria, they fulfilled this standard. 3-5-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. This standard was fulfilled when the students progressed to the decorative phase of their instrument creation.

The Common Core Mathematics standards, obtained from the Common Core State Standards Initiative (2018) that were utilized in this project were: 3.G.A.1: Understand that shaped in different categories may share attributes and that the shared attributes can define a larger category. Recognize rhombuses, rectangles, and squares as examples of quadrilaterals and draw examples of quadrilaterals that do not belong to any of these subcategories and 3.G.A.2: Partition shapes into parts with equal areas. Express the area of each part as a unit fraction of the whole. Concepts addressed by these standards flowed into conversation among students while creating their instruments, which reinforced what they had already learned.

The State of Iowa Core Social Studies Standards (ISSS, 2017) that were fulfilled by this project were SS.3.1: Identify disciplinary ideas associated with a compelling question and SS.3.5: construct responses to compelling questions using reasoning, examples, and relevant details. The students created this project at the end of their learning experiences on sound, which allowed them to determine the disciplinary ideas and use reasoning, examples, and relevant details to create their sound machines.

Method

This STEAM activity, Recycled Sound Machines and Music Makers, was a collaborative project with the elementary art teacher at the school. This project took place over the span of two class periods during the students' shared art time. The project was supplemental and occurred prior to the conclusion of the students' investigation of the physics of sound. The lesson highlighted student learning through this final STEAM project. The overall objective of the activity was to allow the third-graders to study concepts of sound and incorporate both the Next Generation Science Standards and the National Core Arts Standards, National Common Core Math Standards, and the State Social Studies Standards. The goal of the project was to allow students to create instruments that were not standard (not typical orchestral instruments) or that they had previously studied.

Setting

This STEAM project involved a class of third grade students who attend an elementary school in the Midwestern United States. The school had approximately 600 students in attendance in grades preschool through third grade. The participating third grade class had eight boys and thirteen girls of eight to nine years of age. The class had nineteen European-American students, one student of Asian heritage, and another of Middle Eastern heritage.

Materials

The students' projects were constructed mainly of recycled materials that the art teacher had available in her classroom. The recycled materials for construction included cardboard items such as cardboard tubes and recycled boxes. Other materials that were available for construction included pipe cleaners, aluminum foil, plastic lids, rubber bands, plastic containers and bells. The students had access to wooden blocks, ceramic tiles, corks, paint sticks, and wooden dowels. The students were given the opportunity to special order items if they desired for the construction of their sound machines.

During the second part of instrument-making, the students were given access to another set of materials. These items were used to make it aesthetically pleasing and included paint, patterned duct tape, foam shapes, sticker paper, ribbon, bling, and pom-poms. The students also had access to glue and glue guns.

The Lesson

The lesson followed a learning cycle lesson format including an engagement activity, exploration phase, explanation phase, expansion phase, and evaluation. This lesson format is explained in the first editorial of this journal (Rule, 2016).

Engagement Activity

The students gathered in the meeting space of the art room for collaborative (collaborative instruction between the art teacher and the regular classroom teacher) art time. During this meeting, the students were informed that they were going to apply what they had learned through their explorations of the physics of sound and, using a budget, they would be designing a recycled sound machine or music maker. Students were shown some of the materials they would be using, thereby sparking their interest in the activity.

Exploration Phase

The students were provided many opportunities to explore musical instruments and sound-makers throughout the course of the unit of the physics of sound. They had also learned how sounds travel through a variety of materials and how sounds get from a source to a receiver.

During the exploration phase, students learned to discriminate between sounds generated by dropped objects. They also attempted to demonstrate how sounds could be made louder or softer and higher or lower. These investigations allowed for the students to explore the physics of sound in the natural and human made worlds by observing and manipulating materials. As students explored and demonstrated their understandings, the teacher was able to determine their knowledge levels and thereby adapt this culminating lesson to meet their needs.

Explanation Phase

After the students participated in each investigation during the unit, the teacher held a class meeting to share findings and to ensure that students were developing correct understandings of the physics of sound. This time allowed the students to discuss what may have or have not gone as planned during their investigations. The students were asked to consider their results from the prior investigations when designing their recycled sound machines or music makers.

Expansion Phase

The students were given the opportunity to apply what they had learned throughout their study of the physics of sound and apply this knowledge to a STEAM-based project focused on sound. The students were asked to create a recycled sound machine or music maker that illustrates something that they had learned through their investigations. The students were given a budget for the project that needed to be followed as they designed, created, and decorated the piece. Their individual budgets were recorded on notecards on which they subtracted from the original $5.00-dollar amount. The budget allowed the incorporation of key concepts from social studies regarding supply and demand as well as math skills involving money. The recycled materials were priced according to supply and uniqueness. The students were also given a rubric (See Table 1) with grading criteria that would be considered upon completion of their project. The students used the first 50-minute collaborative art time to design and create their recycled sound machine or music maker.

The second phase of the project took place a week later, and these 50-minutes of collaborative art time focused mainly on making their sound machine visually appealing. Once again, the items that were to be used in the beautification process were priced according to supply and demand as well as uniqueness. The students had to use what they had left in their budget to make their sound machine look like something other than recycled materials that had been glued together. Figure 1 shows one of the boxes of materials from which students could choose to decorate their work. Figure 2 shows students considering various recycled items for their sound makers.

Table 1. *Rubric for Scoring Student Projects*

Grading Criteria	Yes	No	Feedback
Does your creation make sound?			
Did you stay within your $5.00 budget?			
Was it a new design for a sound machine or music maker?			
Did you make it visually appealing?			

Figure 1. This student is considering the different materials for decorating her sound maker. The cost for this item was $0.25 for unlimited use to make the project visually appealing.

Figure 2. The students were exploring the materials they wanted to utilize in the design of their recycled sound machines. These boys were trying to make the best use of the budget and find items that would withstand the planned actions needed to make sound.

Evaluation

This project served as a performance assessment of the third-grade students' learning and was used in addition to the summative assessment developed from the adopted text series and science kit. The students and teachers both used a rubric to assess the STEAM project. The rubric criteria had been presented prior to beginning the project and was posted for consideration throughout the entire project.

Student Products

The third-grade students produced a variety of recycled sound machines and music makers. All the students used their entire budget on the materials for the project and completed the assignment in the sessions provided. The students separately demonstrated their finished products, creating sound for the entire class and the teacher. The creativity of the students was evident and well-depicted through their innovative designs and creations. Figure 3 depicts the *Ton of Fun* sound machine. In her original design, the student created a single drum. However, she revised her design to create a music maker that was able to produce both the sounds of a drum as well as a maraca.

Some students' creations were so innovative that they were hoping a toy company would notice them, as in Figure 4, The *Puppy Shaker*. This student was creative and thoughtful in her design. The head of the puppy serves as a maraca, the ears of the puppy held the collar containing a bell in place, and the four legs of the music maker were mini bongo drums.

Figure 5 depicts one of the student projects called *The 3 in 1*. The student created this sound machine by incorporating the aspects of sound from a maraca, rain stick and a drum into his design.

The creativity of the students continued to surprise the teacher as their innovative ideas came to life. One student even created a *One Woman Band*, as she infused what she learned throughout the sound investigations into the design of her music maker! See Figure 6. The creativity of the third-grade students was STEAM-azing!

Figure 3. Ton of Fun Drummer Machine – This sound machine is a combination of a drum and a maraca.

Figure 4. Puppy Shaker – This is a percussion instrument. It is played by shaking the puppy or tapping on the drum legs. The design of the puppy allows the ears to hold the collar in place that contains a bell.

Figure 5. Three In One – This recycled sound machine was created by combining the ideas for a drum, a maraca, and a rain stick.

Figure 6. One Woman Band.

Conclusion

The students' creations of recycled sound machines and music makers were a success. They used their knowledge of the physics of sound to create many STEAM-azing projects. The depth of knowledge that they students applied, and their creativity showed in their designs. Some of the students took multiple aspects of sound and combined them together to create a new sound machine. Students were empowered as they designed and created their projects. This type of project allowed students to show their learning in a completely different setting and provided opportunities for success.

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