Flipping about the Sun and its Pattern of Apparent Motion

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Abstract

Arts integration has shown to enhance student comprehension, retention, and engagement, while connecting to rich science content. The integration of the Next Generation Science Standards and the National Arts Standards into a first grade lesson illustrated how the arts enhanced the students' understandings of the sun's apparent motion during the day, an idea that is difficult for many young children to grasp. In this project students explored the sun outdoors throughout the school day to document changes by tracing their shadows in chalk and by making a shadow clock. Students also applied the information they learned to the creation of a flip book depicting the motion of the sun in the sky during the day.

Key Words

STEAM, STEM, shadows, sun, sundial, first grade, early childhood, practical lesson.

Introduction

STEAM (Science, Technology, Engineering, Arts, and Mathematics) is not the next magic bullet; however, this arts-integration instructional approach provides the opportunity for teachers to address the many areas where art intersects with these disciplines (Wynn & Harris, 2012). Arts integration has been shown to have many benefits for students including long-term retention of information learned through mechanisms that naturally occur when the arts are integrated (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011). For example, students getting ready to perform in front of a group are naturally motivated to practice what they will say or do, thereby reviewing content through the mechanism of rehearsal. Arts integration also has strong positive effects on student motivation (Land, 2013).

The lesson on light, shadow, and the apparent motion of the sun featured in this article took place in a first grade classroom in a small Midwest city. The lesson explored integration of the arts into STEM (Science Technology Engineering and Mathematics) to produce what is termed STEAM education (with the "A" representing the arts.

Literature Review

In this brief review of the literature, first, the benefits of arts integration are described, followed by a review of other published lessons in which shadows have been explored. Then, the national standards addressed by the lesson are explained. Following the review of the literature, the lesson processes incorporated by the teacher are described and illustrated through pictures and through the results of the project.

Benefits of Art Integration into STEM

Attention and cognition have been shown to increase in efficiency when repeated activation of the brain's attention networks. Eight natural arts integration mechanisms that impact student retention include: rehearsal, elaboration, generation, enactment, oral production, effort after meaning, emotional arousal, and pictorial representation (Rinne et al., 2011). Practicing a skill, or rehearsal, either in the arts or in other areas, builds a rich collection of information related to the skill. The arts connections in the brain become more tightly integrated and stronger.

Arts integration is showing promise as a large body of scientific evidence indicates that repeated activation of the brain's attention networks improves their efficacy (Posner & Patoine, 2009). Research on how arts training improves focus (Posner & Patoine, 2009) suggests that resolution of conflicts among competing possible responses plays a role. For example, in music instruction, children need to attend to a specific conflict, such as which note to play. This practice in focusing on the optimal response strengthens this ability in other areas of academics. Coupled with engagement in an art form, in which children sustain attention for larger periods of time due to the high interest level, preparation in the arts improves attention and cognition.

Through arts integration into STEM, students are provided opportunities to rehearse and elaborate on skills that are connected to prior knowledge. Students who rehearse science content through the arts find it engaging, motivating, and effective (Rinne et al., 2011). Arts-integrated lessons have been shown to connect concepts of the learning in a more meaningful way, while allowing students to add detail to their ideas with the arts. Students, through arts integration, naturally utilize the eight previously mentioned mechanisms found to support learning (Rinne et al., 2011).

Shadow Understanding through Art

Students play outdoors during recess; however, getting to explore the outdoors during science class is a great opportunity from a child's perspective. Understanding of the difficult concept of how shadows are made can be enhanced when students trace the shadow of an object at different times of the day. Young children are involved in many scientific experiences in their everyday lives as part of their experiences in the world around them each day (Chen, 2008). However, very little research has been conducted on young children and their conceptions of shadows.

A study (Feher & Rice, 1988) of children aged eight to fourteen found that only about a quarter of the 40 participants were able to identify how a shadow formed. Another previous investigation (Guesne, 1985) found that children aged 10-15 regarded shadows as reflections of objects when trying to identify the definition and formation of shadows. Most studies only investigated children's concepts about shadows verbally with the exception of Chen (2009). Chen compared the views of four and five-year-old children while allowing manipulation of objects to illustrate children's understandings of how shadows are created and how they can be manipulated to vary size, intensity and shape. The design of the lesson described in this article includes hands on shadow exploration of first graders and depiction of them through the creation of a sun dial and a flipbook of drawings of shadow changes.

National Standards Addressed by the Project

The Next Generation Science Standard (NGSS; NGSS Lead States, 2013) for first grade supported by this lesson was *1-ESS1-1: Use observations of the sun, moon, and stars to describe patterns that can be predicted.* This standard was addressed through student observation of the sun and how the shadow that it produces can be predicted. This standard was operationalized when the students

illustrated their own shadow book depicting various real life objects and the shadows that they cast throughout the day. Another standard was also supported: *K-2-ETS1 Engineering Design: Asks questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool*. This standard was addressed as students worked to design their own shadow clocks to help determine the time of day. Then students integrated art into their shadow clocks to make them more appealing for people to use.

Two of the National Core Arts Standards (National Coalition for Core Arts Standards, 2014) were also addressed in this project. The first standard related to the project was *MA: Cr1.1.1: Express and share ideas for media artworks through sketching and modeling*. This standard was supported as students sketched their objects and depicted the shadow that they would cast dependent upon the sun's location. In Visual Arts, the standard *VA: Cr1.2.1a: Use observation and investigation in preparation for making a work of art* was demonstrated when students observed and investigated the sun to see how its location determined the shadow placement and how the shadow moved dependent upon the sun.

Method

Students in the first grade classroom were working on discovering patterns of the sun, moon, and stars in the sky. This set of lessons focused on just the patterns of the sun, especially how the sun rises in the east and sets in the west during each day. Students used this pattern to then design their own shadow clocks and flipbooks.

Setting

The elementary school at which the lesson took place is a kindergarten-fourth grade elementary school in a small city in the Midwestern United States. Approximately 220 students of varying ethnic backgrounds, with the majority being Caucasian, attend the school, which has strong family and community partnerships. The classroom that participated in the lesson was made up of 20 first-grade students, nine boys and 11 girls.

Materials

During these lessons, students used a lot of basic classroom materials. The teacher used multiple videos from Youtube for all students to view. These videos were *Sun moving across sky until sunset* (Jones, 2012a), *The sun traveling across the sky* (Jones, 2012b), *Flip-book valentine cards by Jen Weston* (Weston, 2013), and *A book to FLIP for* (Spangler, 2008). Students used small whiteboards, sidewalk chalk, notebooks, construction paper, markers, crayons, tape, plastic cups, and large craft sticks. A large cement-floored area outside was also used.

The Lessons

Engagement Activity

"What is a pattern?" All students were asked to write on their whiteboards what they thought a pattern was, and a few responses were shared with the whole class. Then each student drew examples of patterns on their whiteboards that involved shapes and repetition.

Exploration Phase

Students shared their responses to "What is a pattern?" with another student before sharing with the whole class. The teacher helped develop the students' understanding that a pattern occurs when one can predict what will happen next. The students brainstormed a list of objects in the sky. Next, students drew or wrote about a pattern they had noticed concerning the sun. A few students were able to write "day, night, day, night". Then they described the pattern verbally as being able to see the sun during the day and to not see the sun at night.

Explanation Phase

Students were shown two videos: *Sun moving across sky until sunset* (Jones, 2012a), and *The sun traveling across the sky* (Jones, 2012b). Both of these videos were shown at double speed. Then students wrote what they

observed about the sun. Each student shared with another student before answers were discussed as a whole class. Students used their hands to trace in the air the path the sun took in the sky. The teacher compared the path to the shape of a rainbow. Then, students thought about what the sun would do the next day. This procedure was repeated two more times.

Throughout a day, the class went outside at 9 a.m., 10 a.m., 11 a.m., 12:30 p.m., 1:30 p.m., and 2:30 p.m. Each student was given a spot to stand on the cement that was spaced out from the other students. The students were advised to not look directly at the sun. The students used sidewalk chalk to trace their feet the first time, so that they could stand in the exact same spot every time. Each student also wrote his or her name by his or her feet to help remember the location. Then a partner traced the shadow of the student's head with sidewalk chalk on the cement. Next the partner drew a line from the shadow of the head back to the tracing of their feet. This same procedure was repeated five additional times throughout the day. After the students did the last tracing on the cement, they copied in their science notebooks what had been drawn on the cement. They, discussed with a partner what they had observed.

The students observed that their shadows had moved during the day. They also observed that the size of the shadow changed during the day. The students explained why the shadows moved. They were able to explain that the sun was moving in the sky during the day, so their shadows were also moving. The teacher explained the concepts of the shadow being in an opposite position from the sun and that the shadows changing lengths due to the position of the sun in the sky.

Expansion Phase

During this phase of the lesson the teacher's small group objectives were (1) students will be able to predict the sun's path throughout the day; and (2) students will problem solve to create a working, visually appealing shadow clock to tell the correct time during the day. Most students were placed into groups of two, while a couple of groups had three students.

The teacher discussed the history of shadow clocks, but did not show pictures of shadow clocks because she wanted students to generate their own designs and not copy previous ones. The students looked at their shadow tracings from the previous day. The teacher provided hints of the connections, but she emphasized using their tracing to help them create a shadow clock that could tell the times on the hour from 9:00 a.m., to 3:00 p.m. They used materials from the classroom to make their clocks. See Figure 1. Some of the clocks did not show correct spacing of times.

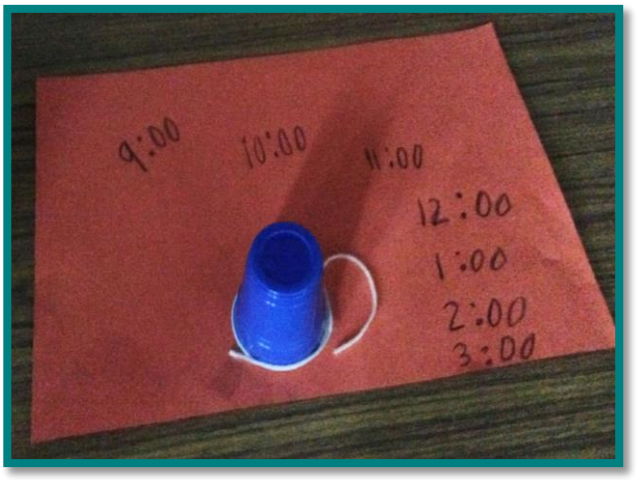

Figure 1: Students' original shadow clocks did not contain correct spacing of times.

The students brought their clocks to the teacher when they thought they had developed a working clock. For a few examples, the whole class observed as the teacher moved a flashlight to simulate the sun's movement through the sky. The students learned from each other's clocks and then modified their own clocks. The groups were allowed to improve their clocks as many times as necessary to develop a correct, working clock. After students had developed a correct sundial clock, they made their clocks more visually appealing. The students were shown pictures from a Google Images search for "sun art" from the Internet. Then the students were told to either create one big sun on their shadow clock or cut and glue smaller printed images onto their shadow clocks to decorate it. See Figure 2 for a central sun illustration and Figure 3 for the use of several sun pictures.

Figure 2: Students' final shadow clock with added artwork of a big sun.

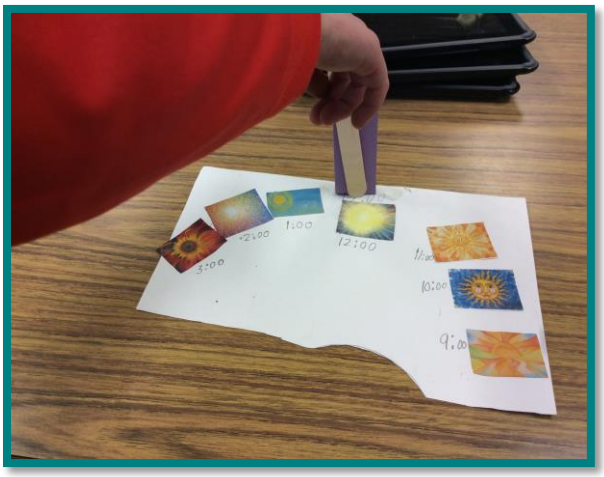

Figure 3: Students' final shadow clock contained artwork of suns for each hour.

Evaluation

Now, the expectation was for students to show individually they could meet the teacher's objectives of (1) students will show the shape of the sun's path throughout the day and (2) students will produce a product of high quality to be shared with others. The students were told they would create a flipbook to show their understanding of the path the sun travelled through the sky. They were shown two videos at double speed explaining how to create flipbooks: *Flip-book valentine cards by Jen Weston* (Weston, 2013), and *A book to FLIP for* (Spangler, 2008). Then the students were given blank flipbooks already constructed for them. The students drew the path of the sun during the day. They started with only using pencils. They drew the sun on the first page, a middle page, and the last page. Then they added the pages in between to show the sun's movement. Finally they added a consistent background to each page. Examples of students' books were shown to the class as a few students completed each step. Color was finally added to the flipbooks. Figure 4 shows several pages from a student's flipbook.

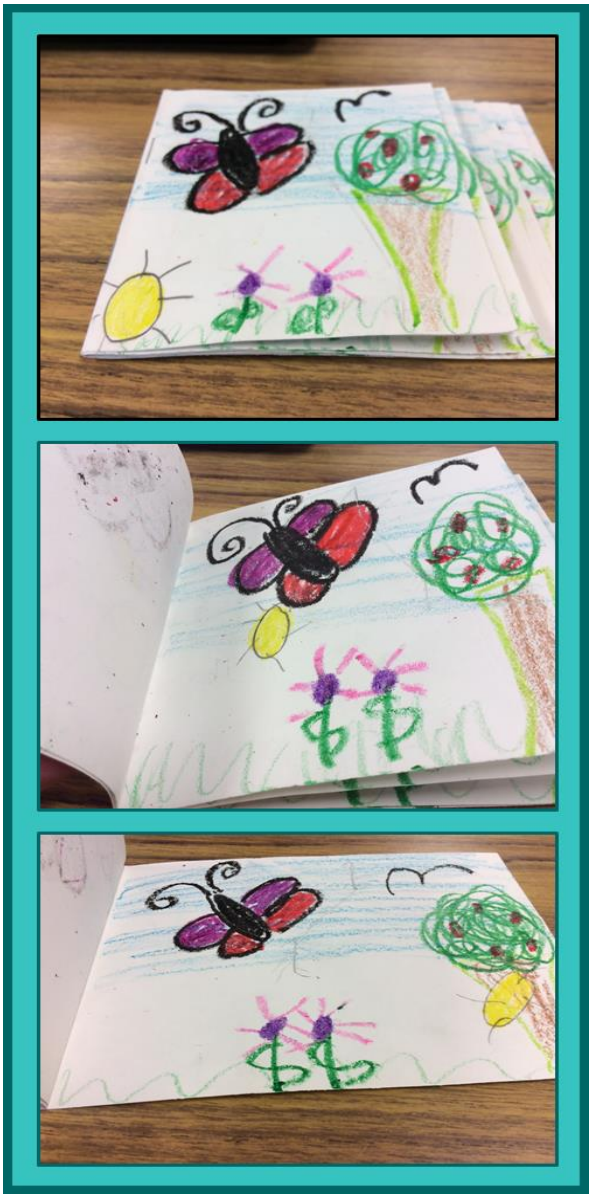

Figure 4. Several flipbook images from a student's work.

Conclusion

The lessons were delivered in a different format than the teacher's typical science lessons. The teacher usually spent 15-20 minutes three days a week for science; however, during this unit, she devoted 35-45 minutes of four consecutive days to the lessons. This time allowed more elaborate and hands-on lessons.

Students' shadows clocks showed a substantial increase in quality and demonstration of understanding from their first construction to their final construction. Students were able to learn from other groups to determine what materials would work well. One group tried to use clear plastic cups for their shadows, but the shadows were very difficult to see. Most students initially wrote the times for their shadow clocks in backwards order. The students really showed persistence when their clocks did not work and they had to go back to redo them multiple times. All the groups were able to produce a working shadow clock. Most of the groups also made the effort to produce a high quality, visually appearing shadow clock (See Table 1). The groups who struggled to meet this objective would have benefitted from example indicators of what a visually appealing shadow clock contained.

Table 1. *Small Groups Meeting Objectives*

Objective	Product Characteristics	Groups Meeting Objective
Students will be able to predict the sun's path in the sky throughout the day	Evenly spaced times Times in correct order 9:00 am on the left 3:00 pm on the right	All groups
Students will problem solve to create a working, visually appealing shadow clock to tell the correct time during the day	Shadow clocks were visually appealing.	Most groups

The students' flipbooks did not initially appear as if they were going to show high quality. Students only wanted to draw. A large number of students struggled with the path the sun took in the sky (See Table 2). Once again the students learned from each other. The teacher selected student examples throughout the individual work time to show students that understood the concept correctly or started producing high quality work. This proved helpful to those struggling. Similar to Feher and Rice's (1988) study of students having difficulty identifying how a shadow is formed, these students were struggling with showing how an object's shadow moves in the book. The lesson was modified to only focus on drawing the sun's path in the sky throughout the day. The students were also informed to help improve the quality of the students' drawing and coloring within their books that the books would be placed in the school's library for others to view.

Table 2. *Individuals Meeting Objectives*

Objective	Student Products	Students Meeting Objective
Students will show the shape of the sun's path throughout the day	Sun starts at lower left hand side Sun is at the top and middle half way through the book Sun is at the bottom right hand side	Most students
Students will produce a product of high quality to be shared with others	Details Variety of colors Neat	Most students

As suggested from previous studies integrating arts with science (e.g., Rinne, Gregory, Yarmolinskaya & Hardiman, 2011) the students were always very engaged in the lessons. Having science class as a longer stretch of time allowed them to maintain interest in the topic and remain actively working on tasks. A surprise that occurred during the lessons was the result of the teacher's hope for students to develop a larger appreciation and deeper understanding of science by integrating the arts. This did happen during the hands on construction of the shadow clocks. The teacher was surprised at the lack of understanding of the sun's movement during the flipbook creation and the lack of interest in this particular activity. Maybe the students would have felt more confident in their understanding of the sun's path, then, they would have enjoyed creating their flipbooks more.

In the future teaching of these lessons, the teacher plans to spend more time directly talking about the sun's path through the sky. She often wanted to give students enough time to work on their activities, and so spend enough time connecting the activities to the science topic. The science standard does not specifically direct students to know about the relationships between the light source, object, and shadow, but in previous years the teacher had spent more time and activities to better develop this concept. This understanding seems to help with students' understanding of the sun's path, so the teacher will probably spend time on this in the future.

Overall, the students really enjoyed working hands-on with this science concept. The students were able to develop an understanding of the concept that the sun has a pattern that can be predicted through various types of observations, videos, and shadows. The students used the skill of perseverance which had been emphasized all year at the school to engineer a shadow clock to tell time. The students developed an understanding of art as a way to enhance the quality of objects. The teacher plans to design science instruction in the future as one larger chunk of time during the week, instead of multiple smaller times to allow students to delve into the science topics and activities more deeply.

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