PENDULUM PAINTING: ART & SCIENCE WHITE PAPER

CEISMC EVALUATION

Go STEAM

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WHAT IS STEAM?

STEAM stands for Science, Technology, Engineering, Arts, and Mathematics, but can mean many different things. For example, some use the "A" in STEAM to represent different arts disciplines (e.g., visual arts, music, or theatre), while others use the "A" to represent broader ideas, like creativity, problem solving skills, or making [1, 2]. Some use STEAM as a way to engage students in STEM through arts projects, such that the arts play a supporting or "subservient" role [3]. Others see STEAM as a transdisciplinary approach to integrating different disciplines, with each discipline valued equally and receiving equal attention in instruction and assessment [4]. We recognize the validity of different ways of defining STEAM, their unique purposes, and the important role of teachers in defining the STEAM approach that works best in their classroom.

Because there is no cohesive definition for STEAM or established set of STEAM best practices [5, 6], we looked for "high-quality lessons learned" in the STEAM literature [7]. We drew on existing models of integration, including Bresler's model of arts integration [3] and the National Research Council's STEM integration framework [8] to develop our own working definition of STEAM. For us, high-quality STEAM instruction involves student-centered instructional pedagogies (e.g., project-based learning, problem-based learning, inquiry learning), group learning, and real-world application to increase cross-disciplinary content knowledge through learning goals for students in both STEM and arts disciplines [9]. We understand that implementing STEAM can be complex and challenging. Thus, we envision STEAM as a continuum, moving from low to high levels of integration, collaborative practices, and complexity of STEAM projects.

WHY STEAM?

STEAM is being used across the globe in an effort to improve student outcomes in STEAM disciplines [10]. Studies in K-12 settings have shown that STEAM can increase students' STEM content knowledge, increase their intent to continuing studying or participating in STEAM, generate positive attitudes towards STEAM, and improve gender dynamics in the classroom [11-15]. With training and support, studies find positive pedagogical benefits for teachers, such as using authentic assessment, integrating technology in instructional approaches, and forming connections with resources and experts outside the school building to support STEAM instruction [16-18]. STEAM aligns well with approaches that allow teachers to step into a facilitator role, supporting student-led exploration, and to engage in collaborative relationships with their colleagues.

GoSTEAM@TECH

GoSTEAM@Tech is a professional development program designed to promote authentic integration of the arts into K-12 computer science, engineering, and invention instruction. The primary goal of GoSTEAM is therefore to create safe, interdisciplinary spaces where meaningful, cross-disciplinary collaborations can occur. Teachers from different disciplines, with the support of university-based coaches and Innovators-in-Residence, come together to design and implement novel STEAM lessons and initiatives in their schools. You can read more about the GoSTEAM@Tech program here: https://steam.ceismc.gatech.edu/.

PENDULUM PAINTING: ART & SCIENCE

LESSON BACKGROUND

In the summer of 2019, two elementary school teachers were inspired to adapt an online lesson to highlight art and science concepts using pendulum painting. In this technique, a pendulum is filled with paint that releases slowly as the pendulum is swung above a canvas. This creates a repeating pattern on the canvas, reflecting the path of the pendulum. The 4th grade teacher and art teacher collaborated to create a multi-week unit in which students explored patterns and force and motion by creating their own pendulum paintings. The goal of the unit was for students to create their own paintings using a pendulum while observing the different patterns that can be made. Through experimentation with the pendulum path, they were tasked with adjusting their pendulums to see how changes to it can affect the outcome of the painting. The teachers spent a week over the summer working at their school with a GoSTEAM Coach to find the right materials and walk through the activity themselves so they could anticipate what the students would experience.

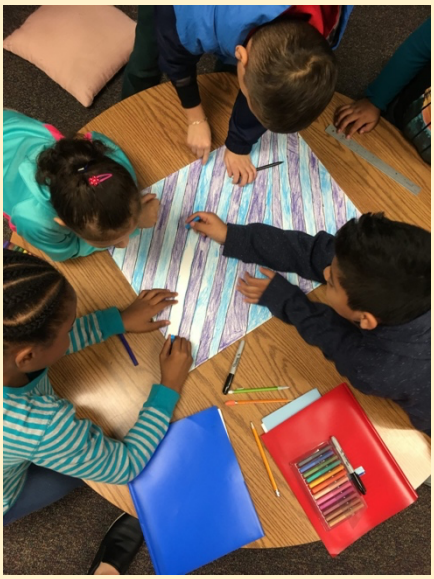
Driving question:
How can simple machines, like pendulums, be used to create art?

LESSON IMPLEMENTATION

The teachers implemented this project-based learning unit in the Fall 2019 semester with one 4th-grade class (approximately 28 students). To begin the unit, teachers covered relevant art and science content, with the arts teacher discussing patterns and the 4th grade teacher discussing simple machines, energy, and balanced and unbalanced forces. During this time, students visited a local art museum to see examples of paintings. Teachers noted that the art museum visit itself was not enough for students to see the STEAM connections reflected in art. While most students enjoyed the museum visit, some were disengaged or thought it was "*boring*." Teachers suspected this was because the museum wasn't very "*hands on*." But when students got to start their pendulum paintings the next day, teachers felt students saw the connection between art and STEM. Indeed, the same students who found the museum boring were the ones who took the lead on problem solving and were most engaged in the pendulum painting activities.

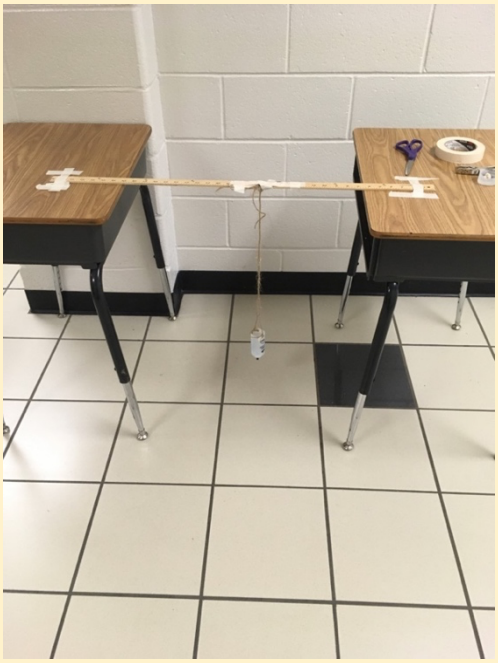
During the first work day, the teachers reminded students of seeing paintings on their recent museum field trip and showed them a video of pendulum painting. Teachers informed the students that they would "*integrate science knowledge with painting and art knowledge*" as they completed their own pendulum paintings. Working in small groups, students completed prediction questions, writing down what they thought would happen when they used the pendulum. Students reflected on a completed example of a

pendulum painting, pointing out the background pattern and a paint pattern in the foreground. The art teacher used this activity to introduce the plan for their work days, telling students they would make the background pattern that day and create the structure of their pendulum. Then they would paint using the pendulum on the following work day. Before allowing students to begin, teachers provided some guidelines for group work, reminding students of important skills they would need to effectively collaborate on the activity, including "*problem solving*," "*creative thinking*," and "*teamwork*." They were reminded to listen to groupmates and share ideas with the group. Lastly, they were told to experiment with their ideas because "*mistakes are ok, STEAM learning is all about trying something*."



A group of students creates the patterned background of their pendulum painting.

Students began work on their background patterns using 11x18" paper. Teachers and the school's GoSTEAM Innovator circulated the room and assisted with problem solving. For example, one group was creating a pattern using diagonal stripes. They informed their teacher that the paper was too long to trace their stripes using a ruler. Instead of providing a solution, the teacher asked the students what they were going to do. Students came up with the solution of using two rulers, which the teacher validated, saying, "*great that's problem solving*." The art teacher was able to share their expertise and encouragement as groups decided on their background patterns. Many groups chose to do stripes as their pattern and the art teacher taught them a trick to remember which color goes in which stripe. Multiple groups then employed this method, making a small dot of color in each stripe so they could remember what color to use when they filled in the entire stripe. This also allowed multiple students in the group to color different parts of the pattern at the same time. One group chose to draw many thin stripes and were falling behind the other groups. The art teacher reminded them that "*as an artist you have to think about how much time you have and how long it's going to take you to do stuff*." She advised them to erase the small stripes and draw bigger stripes to speed things up. Teachers also prompted students to consider aesthetic choices, like considering specific colors ("*that's teal, it has more green in it than that blue. Does it match the peachy orange?*") and the force with which they pressed the crayon to the paper to create darker or lighter shades. This attention to technique reinforced students' skill development and agency as artists, with one student telling their group, "*we are professional artists*."

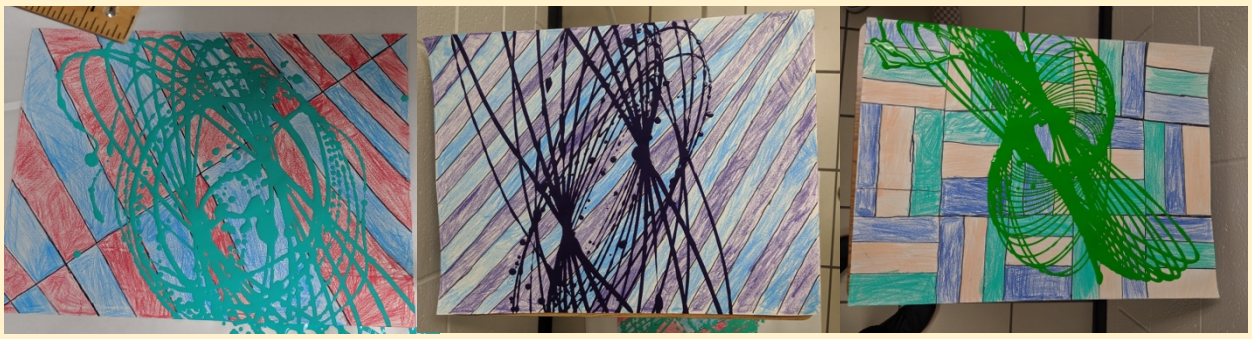


The pendulum device suspended from a yard stick between two tables.

After students prepared their background patterns, they transitioned to building their pendulums. This was done using a yard stick taped between two desks, suspending a small tube in which paint would be poured. The Innovator helped students hypothesize how their pendulum construction might change the pattern of their painting. For example, he asked students to consider how the length of the string might impact the height of the pendulum and the

pattern it would create. In another group, the Innovator asked students what they thought would happen if they moved their pendulum in a circle – would the circle stay the same forever? The group answered yes, at which point the Innovator asked a series of questions to remind them about "*gravity*," "*force*," and "*momentum*" that would cause the circle to get smaller and smaller the longer it was spinning in the pendulum. Students were then able to understand how these science concepts were connected to the pendulum's movement and the pattern made by the paint. One teacher noted that troubleshooting and hypothesizing of this nature took students longer than she expected, but teachers and the Innovator were able to prompt students through questioning and helping them observe other groups' work. Halfway through pendulum construction, the 4th grade teacher assigned one student in each group to take notes, writing down all the choices that the group had made and why. At the end of the lesson, the teacher asked all students to write in their STEAM notebooks about what they did that day and refer to the note taker for help. They were also supposed to predict what would happen on the following build day, when they added paint to their pendulums to complete their artwork.

Overall, students were engaged and focused throughout the build days, needing very few reminders about what they were supposed to be doing in each stage of the activity. The class included a number of students who were designated as English as a Second Language (ESOL) students. These students flipped between English and Spanish throughout the lesson and were able to fully engage with the activity. Students were comfortable working in teams and teachers reinforced a collaborative, growth mindset by encouraging students to troubleshoot problems by discussing with their groups or viewing other groups' work for inspiration. Students were able to successfully complete their paintings on the second build day, displaying them in the hallway of the school for their peers to see. The teachers felt that the STEAM unit was a meaningful experience because of the engagement they witnessed and the process of learning through trial-and-error that students experienced.



A selection of students' completed pendulum paintings.

CHALLENGES & RECOMMENDATIONS

Teachers planned the pendulum painting unit during the summer but struggled to do any additional school-year planning due to a lack of common planning time. The GoSTEAM Coach who assisted teachers with the lesson planning over the summer was able to support their lesson implementation by advocating with the schools' administration to get teachers the time and resources they required. This helped ensure the arts teacher had a sub to cover their regular classes on the project build days. While the school's GoSTEAM Innovator was able to offer support on build days, they did not join the team until shortly before

the project started, meaning that they could not assist with much of the project planning. As the teachers implemented the activity, they were already discussing ways to add additional STEAM elements in future years, such as measurement, by teaching students to use a ruler and having them make calculations to see how many stripes would fit on their background paper.

In light of these challenges and lessons learned, teachers recommended involving administrators in project planning to help ensure that time (including common planning time) and resources are available. In addition, teachers noted the need for flexibility to respond to changes during the school year. The support of GoSTEAM allowed teachers to pivot more easily, especially through the Coach and Innovator collaboration, who helped secure supplies, communicate with the administration, and offer classroom support as they unit was implemented.

KEY TAKEAWAYS

This lesson required careful planning and collaborative time between teachers, which resulted in an integrated unit that supported instruction in arts and STEM. With the support of GoSTEAM, teachers successfully collaborated to guide students through an experimental process exploring the role of simple machines and forces in artmaking. The hands-on nature of the activity was engaging for students, including those who were English language learners, and built off of a recent fieldtrip to a local museum, helping students see arts and STEM connections in action.

RESOURCES

Below are links to resources that may support implementation of similar STEAM projects:

STEAM Pedagogical Approaches: A brief compilation of different pedagogical approaches for STEAM teaching. https://steam.ceismc.gatech.edu/pedagogical-approaches/

Pendulum Painting Activity Guide: A guide for pendulum painting developed by Innovation Kids Lab. This guide served as one source of inspiration for teachers as they designed the GoSTEAM Pendulum Painting unit. https://innovationkidslab.com/pendulum-painting/

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