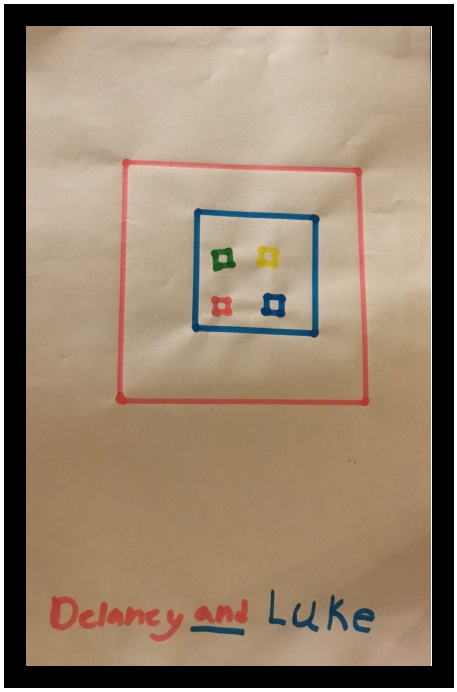
Just Following Instructions

Created by Tiffany Davis
for the STEM Education Center at WPI's STEM Educator Certificate Course

Subject: Math,Art,DLCS **Grade Level:** 2 **Standards:** MA STE,DLCS,Art,Math & ELA (Common Core)

Snowball Fight by Maggie & Gianna, Grade 2
"Divide your paper into fourths. Use lines and shapes with no edges or vertices. Use complementary colors. Make it look like a snowball fight."



Wall Drawing #1
by Delaney and Luke, Grade 2
"Divide your paper in half. Add squares inside of squares. Use warm and cool colors, going around."

Overview

In this STEM Challenge, students begin with a problem: can you program a robot to create a Sol LeWitt-inspired geometric wall drawing?

American artist Sol LeWitt is best known for his instructional wall drawings. A proponent of minimalist, conceptual art, LeWitt famously hired other people to create installations using his written directions. The mathematical nature of LeWitt's directions, which reference lines, shapes, angles, and patterns make LeWitt's work a great starting point for STEAM learning.

The title of this project, "Just Following Instructions," refers to more than LeWitt's method for creating art. Students not only write mathematically-based instructions for making a drawing, much like LeWitt's, but also translate those instructions into code that a robot can follow.

Standards

Note: Detailed learning targets and suggested vocabulary can be found here

Grade 2.Geometry A. Reason with shapes and their attributes.

1. Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces. Identify triangles, squares, rectangles, rhombuses, trapezoids, pentagons, hexagons, and cubes.
2. Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.
3. Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.

Grades K-2, DLCS, Programming and Development

K-2.CT.d.3: Individually or collaboratively, create a simple program using visual instructions or tools that do not require a textual programming language (e.g., "unplugged" programming activities, a block-based programming language).

Grade 2, ETS1. Engineering Design

2.K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.

Visual Arts

- 2.2: For line, explore the use of line in 2D and 3D works.
- 2.4 For shape and form, explore the use of shapes and forms in 2D and 3D works.
- 2.5 For pattern and symmetry, explore the use of patterns and symmetrical shapes in 2D and 3D works.
- 2.6 For space and composition, explore composition by creating artwork with a center of interest, repetition, and/or balance.

ELA, Grade 2 Speaking and Listening Standards [SL]

Comprehension and Collaboration 1. Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.

- a. Follow agreed-upon rules for discussions.
- b. Build on others' talk in conversations by linking their comments to the remarks of others.
- c. Ask for clarification and further explanation as needed about the topics and texts under discussion.

Presentation of Knowledge and Ideas 4. Tell a story, recount an experience, or explain how to solve a mathematical problem with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences and using appropriate vocabulary.

ELA, Grade 2 Language Standards [L]

Vocabulary Acquisition and Use 6. Use words and phrases acquired through conversations, activities in the grade 2 curriculum, reading and being read to, and responding to texts, including using adjectives and adverbs to describe.

Math Practice #6, Attend to Precision

DLCS Practice #5, Communicating

NGSS Practice #5, Using Mathematics and Computational Thinking

Assessment

Performance Assessment Rubric

Prior Knowledge

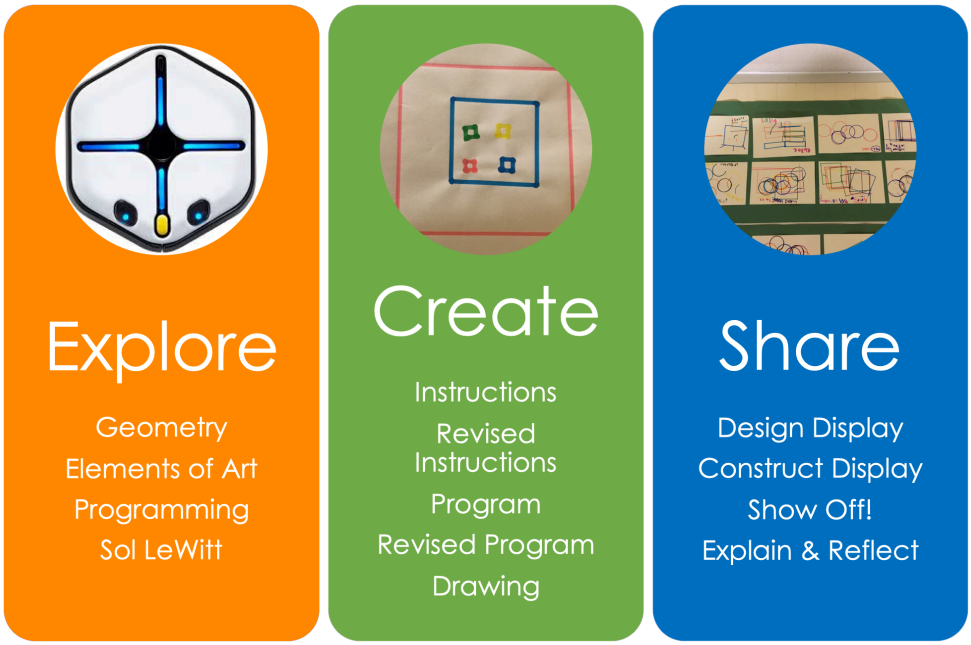
This STEM Challenge is the middle phase of a larger STEAM unit in which students use a three-step engineering design process—Explore-Create-Share—to design and build an art installation/exhibit.

BEFORE this challenge, students engage in the "Explore" phase where they learn and practice with concepts from math, computer science, and art that they will need to succeed in the Create phase.

- Geometry—reason with shapes and their attributes,
- Computer science—using a block-based language, program a robot to draw lines, 2D shapes and patterns. Click here for a copy of the practice checklist.
- Art—identify and explain elements of art (line, shape and color) and principles of design (balance and rhythm) in geometric wall drawings created by Sol LeWitt.

Ideally, the Explore phase will be co-taught by the regular classroom teacher (who will introduce geometry concepts), the art teacher (who will introduce the elements of art and the work of Sol LeWitt), and the technology teacher (who will introduce programming concepts).

AFTER this challenge, students engage in the "Share" phase, working together as a class to design and build an exhibit to organize and display their geometric wall drawings.



Engineering Design Process Visual

Materials

- Paper, colored pencils and rulers for the "hook" activity (lesson #1).
- Programmable robots that can draw and devices with appropriate software. You will need one robot/device for every two students. We used the Root robot, Root Coding app, and iPads. See the Technology section for more information.
- Dry erase markers and whiteboards for practice drawings. Both come with the Root robot, although we needed extra/replacement markers (Expo markers fit in the Root).
- Regular markers and large, thick drawing paper for final drawings (we used 12" x 18" tagboard). Mr. Sketch markers fit the Root robot.
- Rulers—half-meter sticks worked best, given the size of our paper.
- Wet wipes to clean stray marker lines created by rogue robots on tables and floors.
- One copy of the engineering journal for each student.

Resources

- Free Geometry Vocabulary Cards
- Root Robot YouTube Channel
- code.org Video Library (scroll down to the bottom to the section on inspirational videos)
- Handbook for Integrating Computational Thinking by the EDC
- What Are the Elements of Art and Principles of Design? and The Art of an Idea: Math and Art Integration with Sol LeWitt's Instruction from the Art Class Curator Blog
- Sol LeWitt: A Wall Drawing Retrospective from MASS MoCA
- Time Lapse Video of Sol LeWitt Installation from MASS MoCA
- Sol LeWitt's Concepts and Structures from the National Gallery of Art for Educators

Timeline of Activities

Each lesson takes one, 60-minute class period. This timeline assumes that students have mastered the skills outlined in the Prior Knowledge/Experiences section.

Complete Engineering Journal for the project available here. Click here for examples of student work using an earlier version of the Engineering Journal.

#	Activity	Instructions
1	Hook and Brainstorm	1. Students use this simplified version of Sol LeWitt's instructions for Wall Drawing 295—"Six geometric figures (outlines) on a colored wall."—to create a drawing. 2. Students compare their drawings and analyze LeWitt's Wall Drawing 295. Think/pair/share: Do the drawings match the instructions? How are the drawings alike and different? 3. Hand out Engineering Journals (one per student) and review the Challenge and "I Can" sections. 4. Partner up students, review cooperative learning rules, and give them time to brainstorm ideas for their designs.
2	Design	1. 2-Minute Burst of Cool: Ikea Cook This Page followed by a think/pair/share: what makes instructions "good"? Introduce the words "precise" and "clear" into the discussion. 2. Review the math and art word banks in the Engineering Journal and remind students of the criteria for the challenge. 3. Students work with their partners to write instructions for a geometric drawing. 4. Students trade instructions with another group and create a drawing using the other group's instructions. 5. Students use the drawings created by their peers to revise their instructions/designs.
3	Prototype	1. 2-Minute Burst of Cool: Computer Science Is Changing Everything (stop at 2:43) followed by a think/pair/share: what is programming or coding? Does everyone need to know how to code? 2. Discuss "pair programming" rules and roles. See the Group Work section for more details. 3. Students program the Root robot to follow their instructions. Tips: • At this stage, students should use the Root's fold up whiteboard and dry erase markers. • Have students mark the size of the drawing paper they will use for their final drawings on the whiteboard. • Start by creating a separate program for each line or shape of each size that is in your design. • Then practice putting all the elements together; figuring out where to place the robot before running each program/drawing each element takes time.
4	Optimize	1. 2-Minute Burst of Cool: The Geometry of Video Games (show picture in the middle of the page) followed by a think/pair/share: why are there three heads? What's the difference between the heads? Introduce the word "optimize" into the discussion. 2. Students use a ruler and pencil to partition their practice paper.

		3. Students use the Root robot to create their designs on practice paper, revising as they go. 4. As partners work on steps 2-3, ask each student to come up to the front of the room and complete a cooperative learning check in. Review the results of the check in at the end of the class period. See the Group Work section for more details.
5	Create	1. 2-Minute Burst of Cool: Time Lapse Video of Sol LeWitt Installation (start at 35 seconds and end at 3 minutes). Discuss: what surprised you? Be sure to raise the following issues: the number of people, the variety of tools, and the time it took to create the installation. 2. Students use a ruler and pencil to partition their final drawing paper. 3. Students use the Root robot to create their final drawing, and sign their work.
6	Share	1. Video conference with Emily Ross from the Massachusetts Museum of Contemporary Art. 2. Students go on a "gallery walk" to view their classmates' drawings. 3. Students complete a journal entry reflecting on their product and process, and how other students solved the same problem.

Culturally Responsive Teaching Strategies

Each lesson begins with a "2-Minute Burst of Cool," a short video or attention-grabbing image that shows STEM professionals from diverse backgrounds engaged in STEM. The "2-Minute Burst of Cool" incorporates three culturally responsive teaching strategies:

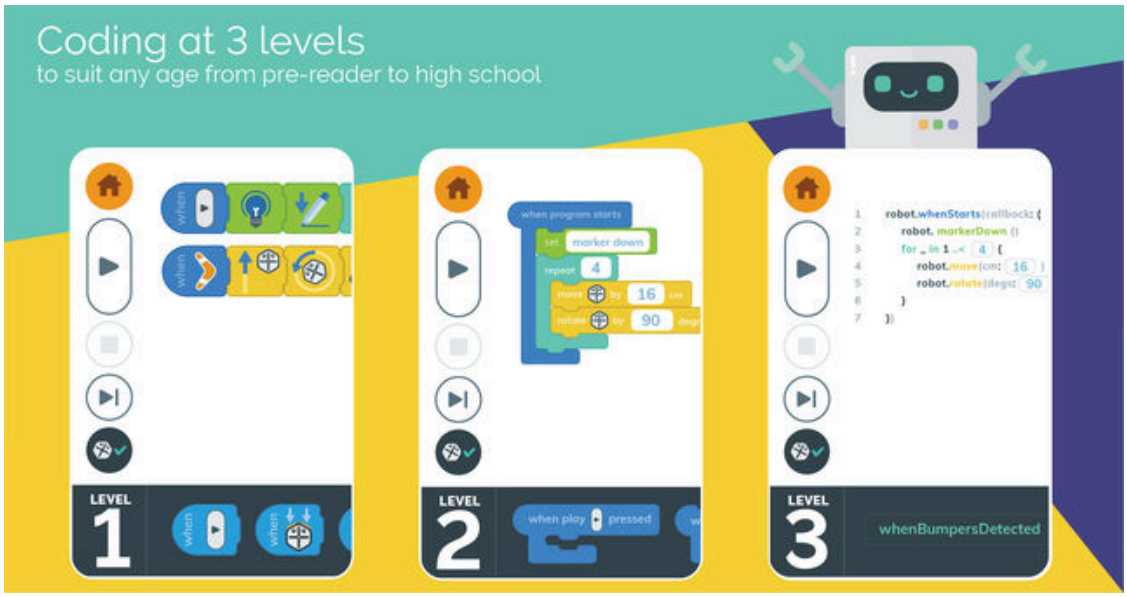
- Activate students' brains before delivering new content/skills in ways that engage feeling and visuals.
- Connect content/skills to everyday life.
- Increase the use of visuals.

Because this is an open-ended challenge with immediate feedback (students can tell on their own if it "worked" or not), students differentiate or find the right level of challenge without much intervention from the teacher. Students who struggle use fewer/simpler shapes in their drawings and students who are more skilled create more elaborate designs. For example, one very skilled group became curious about how many sides the Root could draw and still close the shape. Turns out it's 20! Some groups were too ambitious in their original designs, but we tried to let them figure that out and redesign on their own. We used an Engineering Journal (see the Student Instructions section) to scaffold the design process for students. Teachers and aides scribed journal entries for students with language processing difficulties. All videos have closed captioning available for our hearing impaired students.

Technology

Students use **robots** from Root Robotics to create their drawings. The Root robot can draw lines and shapes by lifting and dropping a marker. Each Root robot comes with a fold-up (non-magnetic) whiteboard, two dry erase markers, and an erasing cloth.

Students use **iPads** to program the Root robot. Root is compatible with any iPad or iPhone running iOS 10 or newer. Android compatibility is in development; there are no other devices planned at this time. The Root Coding app is free, and offers three levels of programming.



Students also use **rulers** throughout the challenge to decide if a shape or line will fit, partition the drawing surface to achieve balance, and position the robot precisely before drawing.

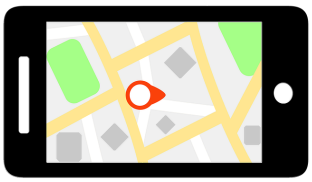
Group Work

Students work in pairs to create their drawings. Prioritize personality over skill level when partnering students— this challenge requires a great deal of precision and persistence, so it's important that students get along. As a general rule, single gender pairs work best for programming challenges, otherwise the boys tend to take over.

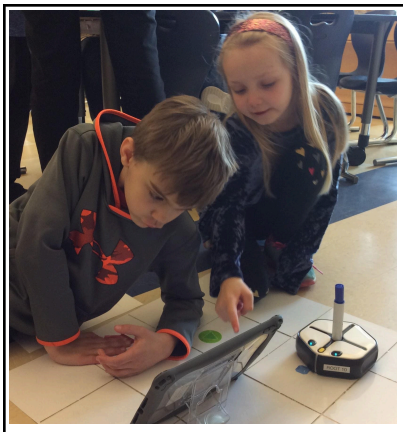
When students are partnered up (first lesson), review classroom rules for working together:

- Listen to each other.
- Help your partner.
- Make decisions together.
- Share the work—no hogs and no logs!

In the third lesson, when students program with their partners for the first time, watch this video from code.org on "pair programming" and review the two roles or jobs outlined in the video.

Navigator: checks the program against the end goal & helps solve problems.	**Driver**: controls the programming device, in our case the iPad.
	

Emphasize that both partners will have a turn with both jobs. Set a timer for five minutes and remind students to switch jobs when the timer goes off. Also stress the importance of having partners sit next to each other so that BOTH students can see the iPad screen.



In the fourth lesson, when students are practicing and optimizing their programs (and usually getting frustrated), call students up one at a time to complete a "cooperative learning check in" on a flip chart displayed at the front of the room. At the end of class, review the results and discuss: how are we doing on working well together?

Career Connections

We connected with Emily Ross from the education department at MASS MoCA (Museum of Contemporary Art) in North Adams, MA. She gave a brief presentation (by video conference) about the museum's Sol LeWitt wall drawings and the different people/roles involved in creating and maintaining the installation, and then answered students' questions.

The "2-Minute Burst of Cool" at the beginning of each lesson also exposes students to a variety of STEM careers.

Possible Extensions

Even though the Sol LeWitt wall drawings that we analyzed in the Explore phase were abstract, some students created works of representational art. Capitalizing on this interest, I experimented in one class with an extra ELA component. After a lesson on Using the Elements and Principles of Art to Tell a Story, students/robots created drawings that told a story, and then students wrote stories to go with their drawings.

For older students, you can incorporate more work with fractions. Here is a lesson on Fractions and Art - Sol LeWitt Style that I used with fifth-grade students.

The Williams College Museum of Art produced a detailed Educators Guide on The ABCDs of Sol LeWitt. The 2D Exploration: Drawing Series lesson that starts on page 26 is a great "unplugged" activity for teaching computational thinking skills, especially abstraction, for students in grades three through five.