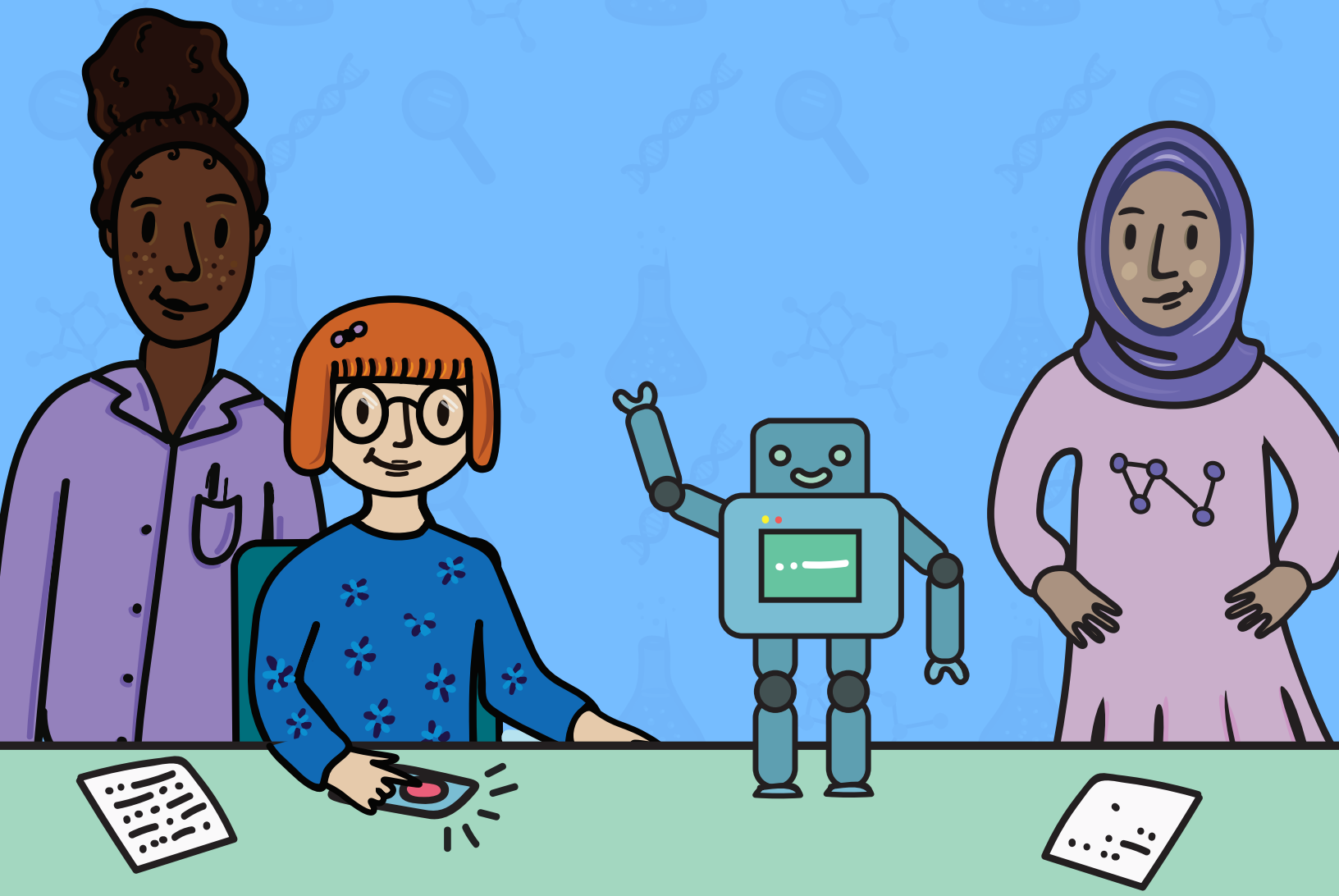
WHAT'S THE CODE?:

CODING ROBOT MOVEMENTS USING SOUND

STEM²D Topics:
Design, Engineering, Science, Mathematics, Manufacturing

Target Audience:
Students, ages 10-14



Smithsonian
Science Education Center

Johnson & Johnson

WHAT'S THE CODE?: CODING ROBOT MOVEMENTS USING SOUND is part of the STEM²D Student Activity Series. The content and layout were both developed by the Smithsonian Science Education Center as part of Johnson & Johnson's WiSTEM²D initiative (Women in Science, Technology, Engineering, Mathematics, Manufacturing, and Design), using a template provided by FHI 360 and JA Worldwide. This series includes a suite of interactive and fun, hands-on activities for girls (and boys), ages 5-18, globally.

Design and illustrations by Sofia Elian

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ACTIVITY DESCRIPTION

In this coding design activity, young students have fun working in teams to design and execute a code for specific robot movements using everyday materials provided for them. In addition to problem-solving, decision-making and creativity, students use interpersonal skills needed in STEM²D careers such as presenting ideas, negotiating, organizing and working as a collaborative team.

ESTIMATED TIME:
This session typically takes 1 hour to complete

STUDENT DISCOVERIES

Students will:

- Participate in a team-based learning experience
- Learn how STEM²D—science, technology, engineering, mathematics, manufacturing and design—subjects are used in designing and executing a code
- Consider STEM²D concepts including, vibration, sound waves and coding
- Become aware of the coding found in Johnson & Johnson careers
- Recognize that STEM²D offers diverse and exciting career opportunities, including that of computer programmers
- Have fun experiencing STEM²D

GETTING READY

Materials: *suggested material preparation prior to the activity with students*

- Activity Leader Checklist
- Tell My Story Form
- Student Handout, 1 per student
- For each pair of students:
  - Polybius square
- For each team of 3-4 students:
  - Robot Movements Secret Code Recording Sheets, 2 copies
  - Masking tape (24 mm wide), 2 strips (30 cm [12 in])
  - Scissors
  - 4 Sheets of construction paper (12x18 inch)
  - 2 Dowel sticks
  - Crayons or colored markers
  - 1 Police/band whistle (optional)
- Certificates, 1 per student
- Camera (optional)

Estimated Materials Cost:
Activity leaders can expect to spend less than $10.00, (assuming scissors, crayons or colored markers are available) in material costs when completing this activity with 24 students organized into six teams of four students.

ACTIVITY LEADER PREPARATION

1. Read **Spark WiSTEM²D.** This is essential reading for all volunteers interested in working with youth, as it provides important background knowledge about STEM²D, strategies for engaging students, and tips for working with groups of students. Download at STEM2D.org.

2. Review the **Activity Leader Checklist** for details and specific steps for planning and preparing to implement this activity.

3. See the **STEM²D Student Activities Overview** for additional information.

STEP-BY-STEP ACTIVITY:

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Welcome and Introductions (10 minutes maximum with this age group)

- Greet the students.
- Tell the students your name and your organization/ company. Talk about your educational and career path. Use the **Tell My Story** form as a basis for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:
    - Your education – focus on secondary and post-secondary classes and courses
    - Current work projects
    - Interests and hobbies
    - Why you love STEM²D, and how your work is connected.

STEM²D Skills

- *Creativity*
- *Decision-making*
- *Negotiating*
- *Organizing information*
- *Problem-solving*
- *Presenting ideas*
- *Teamwork*

TIPS FOR STARTING CONVERSATIONS

- Conversation Starters are provided throughout and include questions designed to introduce students to the activity topics. Use the questions—modify them, or add others—to engage your students.
    - Write your introduction ideas here.

_____
_____
_____
_____

- Ask the students or any volunteers helping today to introduce themselves.
- Use Conversation Starters to learn more about the students and their interests.
- Discuss the opportunities that exist in the local community to support students as they develop their interests and personal experiences.
- Tell the students that your career is only one of the many careers available in STEM²D – science, technology, engineering, mathematics, manufacturing, and design.
- Explain that STEM²D careers are **high-demand**, **high-growth careers**

and are predicted to remain in demand over the next 10 years.

- Some STEM²D careers do not require a college degree and offer young people exciting, high-paying opportunities. Stress the importance of gaining mathematics skills and engineering practices to succeed in any STEM²D career.

CONVERSATION STARTERS: *CAREER PLANNING*

- When you consider your future, what are you most excited about?
- Do you see yourself working with others, for a large company, with your friends, for yourself? Why or why not?
- What does the perfect work day look like to you? Are you outdoors? Are you working alone, or with others? Do you solve problems? Do you fix or build things?

Instructions

- Have students talk about codes. Discuss the following codes:
  - **Barcode**
    - o Ask if they have ever heard of a barcode.
    - o Do they know what it is? It is a machine-readable code in the form of numbers and a pattern of parallel lines of varying widths, printed on and identifying a product.
    - o Who uses barcodes?
  - **Baseball**
    - o Think of a baseball game.
    - o Do they see coaches or players sending codes to each other?
  - **Racing**
    - o Flags are often used as codes in car and boat races.
    - o In racing, what does the chequered flag mean? It means the race is officially finished.
  - **Smoke Signals**
    - o Explain that sending a smoke signal is one of the oldest forms of visual communication over a long

Flags are often used as codes. In racing, the chequered flag means the race is officially finished.

distance by code. Smoke signals were mostly used to warn others of danger or to call people together.

- Puffs of white smoke were made by putting a wet blanket over a smoking fire that was on a high hill. Once the blanket stopped the trail of upward smoke, it was quickly pulled off the fire to send a white puff of smoke skyward. The blanket was put back on to send another puff if needed for the message.
- The most common messages were:
  - ✓ *One puff of smoke meant, Attention.*
  - ✓ *Two puffs of smoke meant, All is well.*
  - ✓ *Three puffs of smoke (or three fires in a row) meant, Danger, Trouble, or a Call for Help.*
- The meanings of the smoke signals often needed to be kept a secret in times of war, and were only known to the senders and the receivers of the smoke signals.

- **These are all examples of visual codes. Ask the class if they know of any sound codes. Talk about the following:**
  - **Marching Band Whistle Codes**
    - Have you ever listened to a marching band?
    - A marching band uses whistles and drums to give signals. When the drum major wants the band to Forward March, the whistle signal is one long whistle, three of 4 counts (123 - 4 silent) followed by four short whistles (1-2-3-4). After which the band starts marching using the left foot first, and the drums help those marching keep the beat.
    - To Halt the band, the drum major's whistle signal is one long whistle, three of 4 counts (123 – 4 silent) followed by 3 short whistles (1-2-3).
    - Use the police whistle to demonstrate the band commands. See if the students can all start to march following the whistle command.

  - **The Tap Code**
    - During some wars, prisoners from the same side were often isolated from each other, they used what was called The Tap Code or Knock Code to send messages. It was a simple code that spelled out words,

letter-by-letter. Messages were sent by tapping the code on pipes or bars to make them vibrate. Other prisoners near the pipes hear the taps and decipher the message. That's how it got its name, The Tap Code.

- The code design they used was not new at all. The tap code was based on a cipher called a **Polybius square**. Polybius was an ancient Greek historian and scholar who liked to use codes.
- The soldiers used a 5x5 (5 rows down and 5 columns across) grid of letters representing all the letters of the alphabet except for the K, which shared the square with the letter C. The Polybius square is used in **cryptography**. A cryptographer is a person who writes or deciphers (solves) codes.
- See the Polybius square below. In **Black**, find the number of taps needed for each letter in **Red**, first by row and then by column.

Polybius Square

0	1	2	3	4	5
1	A	B	C/K	D	E
2	F	G	H	I	J
3	L	M	N	O	P
4	Q	R	S	T	U
5	V	W	X	Y	Z

- Explain that the person receiving the code had to listen to the timing of the taps to figure out the letter(s) being sent. Each letter has two sets of numbers to be tapped. The first set of taps tells which of the 5 rows the letter is in. The second set of taps tells which of the 5 columns the letter is in. For example: M would be 3 taps, a pause, and then another 2 taps.
- The pause between the letters is always longer than the pause between the

two sets of taps needed for each letter.

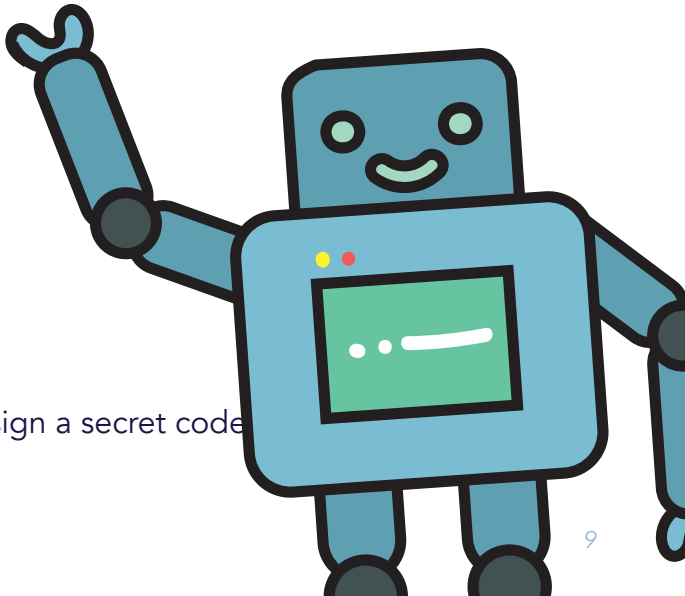
- To communicate the word "FOOD", **the cipher**, or message written in a secret code would be the following: 2-1, 3-4, 3-4,1-4. For clarity, an X is placed at the end of a sentence, and a K acknowledges that the message has been received..

Using the Tap code

- With teacher assistance, divide the class into pairs and pass out a **Polybius Square** to each pair.
- Have each student write out a 3-5 letter word in using the Polybius Square tap code.
- Using the materials provided, ask each pair to send their secret word messages to each other. Ask who was able to **decipher** the code. (As an extension, students can find other students to whom they can send a Tap Code word and even a sentence. You may want to write out a message for each student to send to the group or one pair to send to another, (i.e. Where can we find water? What time is it?)

Designing a Code for a Robot

- Tell students they will now use what they learned about codes to design a code for a robot.
- Ask the teacher in advance to divide the students into teams (4 students per team).
- As a class, discuss or make a list of movements a robot might make. Students should generate some of the following ideas:
    - o Forward one step
    - o Backward one step
    - o Turn around
    - o Jump
    - o Right arm up and down
    - o Left arm up and down
    - o Right foot up and down
    - o Left foot up and down
    - o Head to right
    - o Head to left
    - o Head center
    - o Sit
    - o Bend over



- Discuss ways each team might design a secret code

rials available, to send a message to a robot using sound. The code should tell the robot how to move. Students may choose to design a Polybius square (see image). DESIGN: Please recreate the table using red as indicated by the writer, labeling it Polybius square.

Polybius Square

0	1	2	3	4	5
1	Head R	Head L	Head center		
2	R Arm up	R Arm down			
3	L Arm up	L Arm down			
4	R Foot up	R Foot down			
5	L Foot up	L Foot down		Jump	Turn around

- Each team should work together to:
  - o Decide the movements they would like their robot to be able to do. Pass out the Robot Movements Secret Code Recording Sheets (2 sheets per team) for the students to use to design their codes.
  - o Create a code for each movement using a series of taps. Make 2 copies of the code, one for the sender and one for the receiver (the robot). Note: the receiver could be one of the other team members who deciphers the code and then tells the robot what to do.
- Select team roles:
  - o The **Robot**, does the movements sent by code
  - o The Robot **Technician**, assists the robot in deciphering the code
  - o The **Scribe**, writes out the movements in the code for the sender
  - o The **Code Dispatcher**, sends the code

- Have teams choose a name for their robot and design a suit for the student robot using the crayons or colored markers, scissors, paper, and tape provided. Much of this can be done by the Robot and Technician while the Scribe and Dispatcher write out the code for the movements they want the robot to do.
- Have the Scribe and the Dispatcher write out the movements in code, in the order they want the robot to perform them.
- Have the Scribe and the Dispatcher send the code to the robot and wait for the Technician and the Robot to decipher the code and perform the correct movement. (Movements may be slow at first but as the students becomes more familiar with the code, the speed should increase.)
- Teams may experience **interference** with their code making it hard to decipher because of other taps being made by other teams to their robot.
- Visit each team as they work and ask open-ended questions that will lead to problem-solving.
    - o What challenges are you having in designing your code?
    - o Did you use the Polybius square? Why or why not?
    - o Do you think your code can be easily deciphered?
    - o What is vibrating that makes the sound?
    - o What interference might you encounter?

Reporting Results:

- Have each team pick one person to report out on the work of their team. Have each robot perform 3 movements using the team code for everyone to hear and see.
- Have the Scribe and Dispatcher of one team send their code to another team's robot. What is the result?
- Give positive feedback after each team presentation and encourage the other teams to applaud their work.
- This is a good time to take pictures of each team.

Student Reflection (10 minutes)

- Distribute the Student Handouts. Have the students reflect on this activity by answering the following questions:
    - o What did you learn from this activity?
    - o Was it fun? What made it fun?
    - o Were you doing engineering or design? Why do you think so?
    - o Are there ways you feel you could improve on your code design?
    - o What other materials would you like to use? Why?

    - What was your biggest challenge in designing and/or deciphering a code?
- After a few minutes ask the students to share their thoughts. If time permits, have the students discuss their response to the following question:
    - Have you ever thought about the people who design and solve codes?
- Thank the students for participating
- This is a great time to present each student with a certificate that has been prepared ahead of time with each student's name and signed by the Johnson & Johnson volunteer.

A career in website development and design would require strong coding skills.

Extended Learning

Here are a few ways to extend the learning:

- Explore other codes such as the Morse Code that are sent through sound.
- Have the students design their own secret codes and see if other students can decipher them.
- Identify jobs that require coding skills.
- Explore how coding relates to computer programing. Have the students interview a computer programmer or invite one to visit your classroom.
- Identity the skills needed to major in computer science.

Vocabulary:

BARCODE: A machine-readable code in the form of numbers and a pattern of parallel lines of varying widths, printed on and identifying a product.

POLYBIUS SQUARE: A grid designed by the Greek historian and scholar Polybius, to give several words a symbol, making a code.

DECIPHER: Convert (a text written in code, or a coded signal) into normal language.

SCRIBE: Person who writes or copies something.

DISPATCHER: Person who sends something to a destination.

CRYPTOGRAPHY: The art of writing and solving codes.

CRYPTOGRAPHER: A person who writes and deciphers (solves) codes.

INTERFERENCE: The process in which two or more light, sound, or electromagnetic waves of the same frequency combine to reinforce or cancel each other.

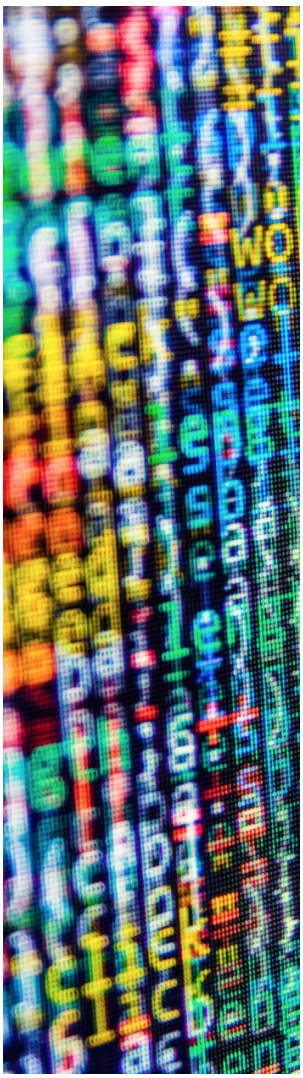
Activity Leader Reflection

After the activity, take a few minutes to reflect on the following:

- What went well and what could be improved?
- What would you do differently next time?
- How comfortable did you feel leading the discussions?
- Do you have a better understanding of the STEM²D concepts?
- How useful was the information presented in Spark WiSTEM²D to implementing this activity?
- Will you volunteer to do this type of experience again?

Cryptography is the art of writing and solving codes.

A cryptographer is a per son who writes and solves codes.



ACTIVITY LEADER CHECKLIST:

DID YOU . . .

- ☐ Read Spark WiSTEM2D? This is essential reading for all volunteers interested in working with youth. It defines the STEM2D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEM2D.org.

- ☐ Visit the implementation site and observe the young people? (optional) If visiting, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the Site Representative?
  - ☐ Confirm the date, time, and location of the activity?
  - ☐ Confirm the number of students attending? Knowing this will help you decide how to group the students into teams, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the Tell My Story Form, which will prepare you to talk about your educational and career path with the students?
  - ☐ If teams are needed for this activity, please ask the teacher in advance to organize the students into teams.
- ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- ☐ Obtain the required materials (see the Materials and Estimated Materials Costs sections) and, if asked for in the Getting Ready section, photocopy the Student Handouts and Materials Testing Sheets. In addition:
  - ☐ Organize the materials to ensure each team has everything listed in the Materials section—keep in mind some materials are shared among the teams.
- ☐ Prepare the space? Specifically:
  - ☐ Make sure tables and chairs are arranged to accommodate teams of students.
  - ☐ Bring a camera, if desired, to take photographs.
- ☐ Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- ☐ Have fun!

"Tell My Story" Form

This form will help volunteers serving as activity leaders prepare to talk about their STEM²D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people, especially girls, will get out of this activity? _____

_____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood where you first had your "spark" or "interest" in STEM.
- Detail your journey; highlight what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

How did you know you wanted to pursue a STEM²D career?

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.*

_____

What your current position entails. *Be sure to include how you use STEM²D on a typical work day.*

_____

_____

POLYBIUS SQUARE TAP CODE

0	1	2	3	4	5
1	A	B	C/K	D	E
2	F	G	H	I	J
3	L	M	N	O	P
4	Q	R	S	T	U
5	V	W	X	Y	Z

ROBOT'S MOVEMENTS
SECRET CODE RECORDING SHEET

ROBOT'S NAME_____

Number of Taps by Rows and Columns

0	1	2	3	4	5
1					
2					
3					
4					
5					

WHAT'S THE CODE? CODING ROBOT MOVEMENTS USING SOUND

Student Handout

Think about the activity. Record your answers to the questions using phrases or pictures in the space provided.

What did you learn from this activity?

Was it fun? What made it fun?

Were you doing engineering or design? Why do you think so?

Are there ways you feel you could improve on your code design?

What are the biggest challenges in sending and deciphering a code?

Did you learn anything about teamwork?

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