Learning Manufacturing with Video Games, Controllers, and MaKey MaKey Circuit Boards

Overview:
This unit focuses on three main components of manufacturing – Mechanical Design, Programming, and Electrical. Students will design and program their own video games in Scratch (scratch.mit.edu). Students will learn about the basics of electricity with MaKey MaKey circuit boards (makeymakey.com). Students will learn about mechanical design through 3D Modeling (tinkercad.com) and 3D Printing their own custom video game controllers.

Goal:
Students will create a video game, design a custom controller for it, and wire it so that the controller is used to play the game.

Unit duration:
5 Weeks (Or 5 meeting times)

By the end of this unit, students will be able to:
- Identify whether an electrical circuit is closed or open
- Create and program a video game
- Invent and 3D Model a controller designed for the video game
- Estimate whether a material is a conductor or insulator
- Communicate three main elements of manufacturing

Materials
- Laptops
- Access to TinkerCAD online
- Access to Scratch online
- MaKey MaKey circuit boards
- Tin foil
- Paper
- Scissors
- Pencils (graphite)
- 3D printers

Resources
- https://makeymakey.com/
- https://labz.makeymakey.com/d/
- https://labz.makeymakey.com/remixes
- https://scratch.mit.edu/
- https://www.tinkercad.com/

Criteria for Measurement of Project Success
- Video game depth and functionality
- Controller layout efficiency
- Controller 3D printability
- Accuracy of circuitry (use of MaKey MaKey)
- Final product must be:
    - A video game, programmed in Scratch, designed to be controlled by the MaKey MaKey circuit board
    - A 3D printed controller, 3D modeled in TinkerCAD, designed specifically for the created video game (and also compatible with some sort of conductor, such as alligator clips, so that it can be used in conjunction with the MaKey MaKey circuit board).

Timeline
2 months prior: Planning/budget (Organize field trip to local manufacturers)
1 month prior: Order supplies, organize speakers, transportation arranged, logistics
2 weeks prior:
1 week prior:
Event held at:

Activity Overview

Week	Activity	Activity outline	Guiding questions
1	**Three parts that manufacturing can be broken into.**	• Session 1 (Preparation) Provide students with an example, such as a conveyor belt or a vending machine, and have them try to guess what the three main components of manufacturing are. Hopefully they come to some consensus resembling mechanical design, electrical wiring, and programming. Finding a fun video on YouTube in which some humorous events are taking place with an example, such as a cat on a conveyor belt, can be an effective illustrative example. Manufacturing can be broken into mechanical, electrical, and programming elements. The mechanical side of things includes physical pieces and parts that need to be designed and fabricated. The programming side of things includes writing the logic that will tell the system what to do and when to do it. The electrical side of it connects the mechanical side to the programming side as well as to things that provide power and action to the entire system. Throughout this unit, students will utilize concepts of the Engineering Design Process – especially the iteration portion in which solutions are built, tested, and optimized over and over again. Before introducing students to the Engineering Design Process, have them engage in a “Tallest Tower” competition. A suggestion would be to have students organize into groups of 3-5 and give each group 5 pieces of paper and 5 pieces of tape. The tower must be freestanding. Give them 5 minutes to build, and the tallest tower wins. Next: Introduce students to the Engineering Design Process through a quick video like this one. Now have students put the design process into practice. In their same groups, have them first identify constraints and criteria. Then brainstorm ideas for 5 minutes. Give a few additional minutes for them to select a design. Students should then take another 5 minutes to build their next iterations. At the end of 5 minutes, the tallest freestanding tower wins.	What three elements are necessary in manufacturing today? How does the Engineering Design Process apply to these parts of manufacturing?

		Reflection should then take place: • Did the design process help in developing the solution? • Do you think that the Engineering Design Process applies to the three parts of manufacturing? In what ways? Explain the overall goal of this experience – to program a video game (programming), 3D Model and 3D print a video game controller for it (mechanical), and to wire the printed video game controller so that you can play your video game you created (electrical). • Where do you think you could apply the Engineering Design Process in this experience?	
2	**Makey Makey Exploration**	• Session 2 The Makey Makey circuit board is a tool that allows a computer to register information such as a button press when an electrical circuit is completed (for example, when a closed conductive pathway is created between the "space" port on the Makey Makey board and the "earth" or ground, the computer will think that you've hit the space bar on the keyboard). To better understand this electrical concept better, give each student a half-sheet of paper and have them crumple it into a ball. Then have the students stand in a straight line, shoulder to shoulder. Take the crumpled paper ball from the student at the end of the line. Hold up the paper ball and explain to students that this paper ball represents an electron. Also provide students with the understanding that electricity is the result of electrons flowing from high potential to low potential (think like a waterfall - water falls from high to low). Explain that they are currently physically set up to demonstrate why an OPEN circuit does not conduct electricity. To demonstrate an OPEN circuit (one where electrons cannot flow): • Explain to students that there are a few simple rules – They can only hold one electron at a time, and if the person next to them does not have an electron, then they must pass their electron to them. Electrons can only flow in one direction in this scenario to simulate direct current. • Since you've taken the paper ball from the student at the end of the line, that student is open and needs to accept an electron. Students pass their electron to the next open student, etc. • Eventually, students will no longer be able to pass their electrons because the student at the end (the one who started without an electron) does not have anyone to pass their electron to.	What is a CLOSED circuit, and how is it different from an OPEN circuit? What is a conductor, and how is it different from an insulator? In what ways might it be beneficial to open and close a circuit – and how might this play a role in manufacturing?

		• With an OPEN circuit, electrons have no closed pathway in which to flow. They just stand still. To demonstrate a CLOSED circuit (one where electrons can flow): • Have students hold on to their electrons and form the line into a circle. • Repeat the same exercise with the same rules. • Students should find that they are able to continuously pass there electrons because the pathway is closed and connected. Instead of the electrons having nowhere to go, they now always have a place to go. Next, distribute Makey Makey circuit boards to students. Explain that they need to create closed circuits between "earth" and whatever other button they are interested in using. Makey Makey resources are listed above and include a gallery of project ideas as well as a list of "apps" that work well with the Makey Makey. In this process, encourage students to experiment and develop an understanding for what the difference between a conductor and an insulator is. Especially important for the video game controller is the discovery that they themselves are conductors and can complete the circuit by touching a Makey Makey button with one hand while touching the "earth" with the other hand. In fact, a "chain" of students can be made – each one holding hands with the next (or touching fingertips) and the Makey Makey can still register some current. Usually after about 4 or 5 people in the chain, too much electrical resistance is present for the Makey Makey to register a closed circuit. Have students set a goal (use the Engineering Design Process) that they can use the Makey Makey to achieve with the time left.	
3	**Scratch Programming**	• Session 3 For this portion of the learning experience, students will need to create accounts in Scratch (see resources above) or utilize a single club account (which means all of the students will be using the same account and have access to all other students' creations.). Students who are new to Scratch should begin with the introductory tutorials in order to learn the ropes. Once they have a feel for it, or if they have had previous experience with Scratch, they should use the Engineering Design Process to plan for the video game they want to create. One of their biggest constraints will be time. Encourage them to take risk while also making sure they get at least a portion of the game developed. They especially need to plan for their game's controls in order to be successful in the next session (creating controllers). Students using their own accounts will be able to continue finishing and	What role does the Engineering Design Process play in designing a video game? How is programming a video game similar to programmed logic in a manufacturing environment? How is it different?

		improving their games after this learning experience (and are encouraged to do so)! Encourage students to use the “help” features within Scratch and to help each other in tackling the design goals of their video games.	
4	**Controller design and modelling**	• Session 4 As a result of Session 2, students should be familiar with how the Makey Makey boards work (needing to close a circuit and having the ability to do so with their own bodies). As a result of Session 3, students should have a video game planned (with controls planned as well) if not partially or completely programmed. Now the students will be introduced to TinkerCAD where they will again need to have accounts set up. Students can again set up individual accounts or use a single “club account” in order to 3D Model their controllers. Walk students through the basics of TinkerCAD and give them time to explore the environment and make whatever crazy object they would like. The initial goal is to get them familiar with how the modeling environment works. Once students have a basic understanding of TinkerCAD, it’s time to take them back to a time before computers when the paper and pencil reigned supreme. Again, as aligned with the Engineering Design Process, students should plan their controllers ahead of time, on paper. They should give attention to constraints such as the “buttons” or controls they need to have, how they should be laid out, how they will be wired, etc. Once students have designed the controller on paper, send them back to the present technology age and have them 3D Model their design. These 3D models will need to be exported as .STL files for 3D printing in Fused Deposition Modeling (FDM) printers. Depending on resources available, the physical printing of controllers may or may not be conducted by the students themselves.	What role does the Engineering Design Process play in mechanical design? How is 3D Modeling and 3D printing a video game controller similar to mechanical design in manufacturing? How is it different?
5	**Wiring controllers with Makey Makey to play video games**	• Session 5 (Closure) Students should invite friends and family to present the video game systems they have engineered and manufactured! In this last session, students will likely have time to finish up any components of their projects that aren’t done (perhaps programming video games further, perhaps printing controllers, etc). Using their learning from the past sessions, they should use the Makey Makey to wire their 3D printed controllers to	What are the three parts of manufacturing, and which parts of your project connect to each one? The Engineering Design Process features an iteration cycle in which you Build, Test, and Optimize over and over again. In what ways did you Build, Test, and Optimize your project

5 (cont'd)		the computer in order to play the video game they programmed. Then, students should present their "final" projects and take some time to see what others have created – show off and have fun!	over the learning experience? In what ways could you continue Building, Testing, and Optimizing it in the future?

Judging Criteria

Category	Criteria	Scale	Score
Design	• Video game design is well planned and programming works • Controller design is well planned and mechanically sound • Wiring works as planned	4-5 – Excellent 2-3 – Satisfactory 1 – Unsatisfactory 0 - Missing	
Methodology	Principles of the Engineering Design Process are used for: • Makey Makey goal • Video game programming • 3D Modeling controller	4-5 – Excellent 2-3 – Satisfactory 1 – Unsatisfactory 0 - Missing	
Construction	• Video game programming is logically organized and works • Controller design and Makey Makey wiring work well together reliably	4-5 – Excellent 2-3 – Satisfactory 1 – Unsatisfactory 0 - Missing	
Creativity	Shows creativity and innovation • Video game follows an original idea • Controller is imaginative and fits the video game in theme and/or function	4-5 – Excellent 2-3 – Satisfactory 1 – Unsatisfactory 0 - Missing	
Presentation	• Clear and professional • Thoughtful responses to questions • Ties are made between the project and the three main components of manufacturing	4-5 – Excellent 2-3 – Satisfactory 1 – Unsatisfactory 0 – Missing	
		Total	