4th Grade Lesson on Electrical Circuits Using Makey Makey & Scratch

Stage 1 - Desired Results

Established Goals

NGSS 4PS3 Energy: 4PS3-2: Make observations that energy can be moved from place to place by moving objects or through sound, light, or electric currents. 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

NGSS Engineering Design: 3-5-ETS1. Students who demonstrate understanding can:

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Washington State K-12 Computer Science Standards Level 1B: 3–5

- 1B-CS-01 Describe how internal and external parts of computing devices function to form a system.
- 1B-CS-02 Model how computer hardware and software work together as a system to accomplish tasks.
- 1B-CS-03 Determine potential solutions to solve simple hardware and software problems using common troubleshooting strategies.
- 1B-AP-10 Create programs that include sequences, events, loops, and conditionals.
- 1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.
- 1B-AP-16 Take on varying roles, with teacher guidance, when collaborating with peers during the design, implementation, and review stages of program development.
- 1B-AP-17 Describe choices made during program development using code comments, presentations, and demonstrations.

4th Grade Science Understandings

Students will understand that...

- Electricity flows through a pathway called a *circuit*
- The circuit must be closed in order for the electricity to flow.
- Certain materials *conduct* the flow of electricity while others *insulate* it.

Students will know…

- That energy is transferred between input devices to a computer, which causes an Event to be triggered in the software.

Students will be able to…

- Identify conductive and insulative materials
- Create a closed electrical circuit
- Apply what they learned to more complex use of Makey Makey & other printed circuit boards

What are the big ideas?

Energy can be transferred through Electric Currents. Electric Current, Conductors and Insulators, Closed & Open Circuits

What specific understandings about them are desired?

Students will understand what is meant by closed and open circuits and why a conductive material is required for electricity to flow.

What misunderstandings are predictable?

Not completing the circuit.

4th Grade Science Essential Questions

1. Why do you think it's important to life on earth that energy can move from place to place?
2. What do you think this quote means: "Energy cannot be created or destroyed, it just changes from one type of energy to another?" (Stanford, Dutta, Gupta, 2018)

4th Grade Computer Science Understandings

Students will understand that:

- Events are actions that cause something to happen in a software program
- Events are triggered by user input
- Key presses & mouse clicks are examples of user input
- Makey Makey sits between the user and the computer and intercepts the input to trigger a programmed event in Scratch
- Comments are a useful thing to use when programming
- X-Y coordinates refer to a location on the screen in Scratch.

Students will know…

- How to use Event blocks
- How to change the location of the sprite on the screen.

Students will be able to...

- Write a simple program in Scratch that moves 1 Sprite around the screen.
- Design their program so their Sprite doesn't move "off" the screen. (They can watch this short video I created if they forget how to do it.)
- Add comments to their code.

What are the big ideas? Events, input, output, comments, x-y coordinates

What specific understandings about them are desired?

- Programmers use *Events* to make something happen, often based on user input. Nothing would happen without Events.
- Users *input* information by interacting with the computer hardware (Makey Makey, keyboard, mouse). *Outputs* are what the computer does in response to our inputs (move a character on screen, play a sound).
- *Comments* can help programmers and people reading their code know why they wrote the code the way they did.
- X-Y coordinates refer to where a Scratch sprite is situated on the screen.

What misunderstandings are predictable?
X-Y coordinates; not knowing you need an event block to map to each input on the Makey Makey board; losing the sprite after multiple inputs.

4th Grade Computer Science Essential Questions

1. Why do you think computers need very specific, step-by-step instructions compared to people?
2. How could explaining something in terms a computer could understand be good practice for humans?
3. What are some programming areas other than gaming that might need to use similar types of input and output?
4. What are some of the unexpected things that happen even though we thought we had everything right in our code? Does this type of thing ever happen in other parts of our lives? What can we do to prepare for the unexpected in coding?
5. Do you think programming is better done alone or working with others? Why?

Stage 2 - Assessment Evidence

Performance Tasks

Students will demonstrate for their class how the objects they have connected to the Makey Makey can be used to trigger Events in their Scratch program. As part of this they will describe to the class:

- What different materials they tried, which conducted electricity & which did not.
- Why they chose the material(s) they did to be the input device for their program.
- Where they had difficulty closing the circuit and what they did to fix the problem.
- Where they had difficulty in their Scratch program; what unexpected things happened and how/if they were able to address them.

After everyone has presented students can go around the class and try each other's projects.

By what criteria will **performances of understanding** be judged?

- Students need to describe at least 7 materials they tested.
- Students should be able to explain why they chose the materials they did (conductivity, aesthetic value, feel etc.)
- Students should be able to describe bugs they found in their program and what they did (if they were able) to fix them.
- Students should have a working circuit that includes a minimum of 5 conductive objects connected to the Makey Makey that enable input to their program.
- Student's Scratch program should run as intended, include comments and recognize input from a minimum of 5 objects connected to the Makey Makey.

Other Evidence

Through teacher observation while they are building the circuits and also writing their Scratch program. Is each student engaged and contributing? Can they answer questions the teacher has about their project?

How will students reflect upon and self-assess their learning? By reviewing the project rubric and responding to the prompts in the Makey Makey & Scratch Engineering Notebook.

- When does/doesn't the circuit work?
- What materials did they try and which did and didn't work?
- What bugs did they find in their program? Were they able to fix them? How?
- What would they tell the next class about what to watch out for in this lesson?
- What are their inputs and outputs? What different Event blocks did they use in Scratch?
- What did they think about writing comments in their code? Why do they think they were asked to do this?
- Students should be able to explain how they worked as a team - why did they choose the roles they did, how they solved problems that they recorded in their notebooks.
- What else could they see themselves using the Makey Makey & Scratch for?

Stage 3 - Learning Plan

Understanding by Design “WHERETO” key (Wiggins & McTighe 2005)

W = Help the students know WHERE the unit is going and WHAT is expected? Help the teacher know WHERE the students are coming from (prior knowledge, interests)?
H = HOOK all students and HOLD their interests?
E = EQUIP students, help them EXPERIENCE the key ideas and EXPLORE the issues?
R = Provide opportunities to RETHINK and REVISE their understandings and work?
E = Allow students to EVALUATE their work and its implications?
T = Be TAILORED (personalized) to the different needs, interests, and abilities of learners?
O = Be ORGANIZED to maximize initial and sustained engagement as well as effective learning.

Materials
Conductive materials: aluminum foil, graphite pencils, fruit, vegetables, coins, screws, paper clips, play dough, copper tape, wire, etc. Non-conductive materials: pompoms, styrofoam pieces, paper, cardboard, wood, items made of plastic, dried modeling clay (no moisture), cloth, dried beans etc. 1 Makey Makey kit per pair of students Makey Makey & Scratch Engineering Notebook 1 for each pair of students; can also be filled in online via a PowerPoint file. (O - *Organized*)

Introduction (50 - 60 minutes)

1. *What prior knowledge do students have about electricity and electrical circuits?* (20 minutes) Break class into groups of 3-4 and give each group a number. Ask groups to discuss what they already know about electricity and electrical circuits. Give the students a link to an already-created Mindmap. One student in each group enters their ideas into the node assigned to their group (source = Gates). Once all groups have entered what they remember, the teacher quickly summarizes key ideas in a separate node on the Mind Map. (W - *Where, What*)

2. *Introduce or remind students of how simple circuits work.* (15 minutes) Show students this PBS Kids Wild Kratts video on electrical circuits. Discuss the difference between conductive and insulative materials. Briefly go back to the Mindmap and see how much intersection exists between the video and the Mindmap. Add to the mindmap if necessary. (R - *Rethink*, *Revise*)

3. *Introduce students to the Makey Makey board*. (10 min) Explain the ports and how they map to different *inputs* (key presses, mouse click) on the computer. Explain the difference between *input* and *output*. Show students how to make a closed circuit using Makey Makey and an unusual material like a banana. Prove that it is a closed circuit by controlling the cursor on the computer using the unusual material. Or alternatively, show this PBS Kids Design Squad video about the Makey Makey board . (E - *Equip* & H - *Hook*)

4. *Demonstrate how to create a simple program in Scratch* (10 minutes) to describe:
    a. The different parts of the Scratch screen (if students are unfamiliar)
    b. The XY coordinate grid that Scratch uses to determine where a sprite is on the stage
    c. How Event blocks are used to make the Sprite do something when the user inputs a command by pressing a key or something on-screen. Code several keys as an example.
    d. Explain what to do if the sprite disappears off the screen. Include a link to a video in the online copy of the Engineering Notebook that shows them how to fix this if they forget. (T - *Taylor*)
    e. How to add Comments and explain why programmers use them.
    f. Show students how they can look at other projects on the Scratch website and comment on them but need to do so responsibly (Digital citizenship)
    (E - *Equip*)

5. *Introduce students to the Makey Makey & Scratch Engineering Notebook* (5 minutes) Explain that this notebook acts as a rubric for the project and all pages must be completed.

6. *Group students into pairs* or allow them to pick a partner (T- *Taylor*)

Programming Scratch Movement (20 minutes)

Students program in Scratch. They must test their program prior to connecting the Makey Makey by using the keys on their laptop they have chosen (e.g. space, arrow keys) for their Events. They will use their Engineering Notebook to record which Event blocks they used, how they used Comments, and any challenges they had or bugs they found while coding. If students are finished with the basic coding with time left over they can add backgrounds, sprites, and (if they have experience with Scratch) try to code a game.
(H - *Hook*; E - *Experience, Explore & Evaluate;* T - *Taylor*)

Hands-On Time with Makey Makey (40 minutes)

Once their Scratch program is working, students will connect the Makey Makey to the laptop and to the materials they want to test. They should record which materials were conductors and insulators and any difficulties they had in closing the circuit in their Engineering Notebook. Once they have chosen the material(s) they want to use for inputs they should complete the rest of their Engineering Notebook (including how they worked together as a pair) to help them prepare for presenting what they learned to the class. (H - *Hook*; E - *Experience, Explore & Evaluate*)

Presentations (20-25 min)

Students take turns presenting their input devices to the class, covering the presentation points listed in the Engineering Notebook. (E - Evaluate)

Wrap up (10-15 min)

Class discussion

1. What students liked/didn't like about the project
2. Ideas for using Scratch with Makey Makey in the future
3. What they learned about electric circuits that they didn't know before they did this lesson
4. What it means to them that energy can change form and why that might be important to life on earth
5. Whether they think we can benefit from having to write instructions in a way that a computer can understand
6. Whether they think comments are helpful in coding

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