Unit: Circuitry and Sensory Substitution Devices

Lesson 4: Evaluating the Prototypes

Author: Alexandra Pike

CENTER for NEUROTECHNOLOGY
a National Science Foundation Engineering Research Center

LESSON OVERVIEW

Activity Time:
One 45 minute class period

Lesson Plan Summary:
In this lesson, students will evaluate their sensory substitution circuit both in terms of engineering and ethics by taking part in a scientific poster session.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- Scientists and engineers communicate their research publicly in order to share their new discoveries and understandings, and to receive constructive criticism and questions about their work. In this way, professionals can build off the work of each other and effectively collaborate on larger projects.
- Tools such as Pugh Charts enable scientists and engineers to evaluate the multiple dimensions of a design and take into account the importance of different priorities.

Design Problem:
Teams will evaluate and present their design solutions in the form of models of sensory substitution devices that have the potential to assist a person who has a lost or impaired sense.

Driving Question:

- How do scientists and engineers share and evaluate their discoveries and designs with the wider scientific and engineering communities?

Learning Objectives:

Students will know…

- The purpose of a Pugh Chart is to numerically assess engineering designs and prototypes in order to make an evidence-based evaluation of its effectiveness
- That scientific poster sessions are an informal but important method of sharing and learning from other scientists and engineers

Students will be able to…

- Speak knowledgeably to different groups of people about their engineering designs
- Evaluate a variety of sensor circuit designs based on relevant and ranked criteria and constraints

Vocabulary:

- **Pugh Chart:** A matrix tool used to facilitate a disciplined, team-based process for concept generation and selection.

Next Generation Science Standards:

This unit builds toward the following high school Performance Expectation (PE). Alignment to the three dimensions of science and engineering education (Disciplinary Core Ideas, Crosscutting Concepts, and Practices) are outlined in the table below. Hyperlinks direct to relevant sections of the Next Generation Science Standards and *A Framework for K-12 Science Education.*

High School Performance Expectations		
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (Grades 9-12).		
Science and Engineering Practices (SEPs)	**Disciplinary Core Idea(s)**	**Crosscutting Concepts (CCCs)**
Constructing Explanations and Designing Solutions *Obtaining, evaluating, and communicating information *Engaging in Argument from Evidence	ETS1.B: Developing Possible Solutions	Energy and Matter *Stability and Change *Scale, Proportion, and Quantity *Systems and System Models *Structure and Function *Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World

Common Core State Standards:

- **CCSS.ELA-Literacy.RST.9-10.6:** Analyze the author's purpose
- **CCSS.ELA-Literacy.RST.9-10.8:** Assess reasoning and evidence
- **CCSS.ELA-Literacy.RST.9-10.9:** Compare and contrast findings
- **CCSS.ELA-Literacy.W.9-10.2:** Write explanatory texts
- **CCSS.ELA-Literacy.SL.9-10.1:** Initiate and collaborate in discussions
- **CCSS.ELA-Literacy.SL.9-10.3:** Evaluate speaker's point of view
- **CCSS.ELA-Literacy.SL.9-10.4:** Present information clearly

- **CCSS.ELA-Literacy.SL.9-10.6:** Adapt speech to context

IGCSE Physics Standards:

- **AO1-4**: Demonstrate knowledge and understanding of scientific and technological applications with their social, economic, and environmental implications.
- **AO2-5**: In words or using other written forms of presentation, present reasoned explanations for phenomena, patterns and relationships.
- **AO3-5**: Evaluate methods and suggest possible improvements.

TEACHER PREPARATION

Materials:

Materials	Description	Quantity
Documents	Student Handout 4.1	1 per student

Preparation:

1. Ensure there is space in the room for groups to hang their completed posters.
2. Invite wider community members to participate in the poster session, so that students have the experience of talking with a wider variety of audiences. Invite parents, admin and other staff, and if possible, even science and engineering undergraduates or postgraduates who would be willing to help model a true poster session.
3. Photocopy Student Handout 4.1 for each student.

PROCEDURE

Explain: (10 min, or do the day before)

1. Pass out the Pugh Chart template and discuss as a class how the circuit designs and prototypes should be assessed (Q8).
2. Explain that they will be participating in a scientific poster session, exactly as scientists often share their work with colleagues. Two group members will stay with the poster and the prototype, and talk with other pairs who walk around asking questions and assessing based on the Pugh Chart. After half of the class period, the pairs will switch.

Evaluate (20 min and 20 min):

1. Use about half the class period for one pair to stay with the poster and circuit prototype, answering questions. The other pair should circulate, each with their Pugh Chart, evaluating the other designs. After 20-25 minutes, swap pairs.
2. Either at the end of the poster session or through discussion the next day, ask students to tally up their Pugh Charts and discuss why certain circuit prototypes scored higher

and others lower, why science and engineering discoveries are shared this way, what worked and what didn't during the design process etc. This is an opportunity to have a rich and thorough discussion both about sensorimotor neural engineering and ethics, as well as the engineering process.

STUDENT ASSESSMENT

Assessment Opportunities:

- As students present, probe their understanding of how their circuit functions, how it aligns to an actual device, what criteria and constraints and ethical considerations they focused on, and how well they understand the engineering process they went through.
- Additional assessment can take place during the discussion afterwards (#2 above)
- A survey can be given about the engineering process again, to compare with students' initial responses (see Teacher Resource 4.1).
- At the end of the unit, a content test can also be given, to assess students' ability to explain in writing how different sensor circuits function (see Teacher Resources 4.2 and 4.3 for a test review and test).

Student Metacognition:

- During the presentations, students can be asked about the poster session they are engaging in. They can be asked to assess their own work in addition to the other groups'
- The final engineering survey can also ask students to reflect on their confidence in the engineering process as well as other tasks - presenting in front of others, troubleshooting with their groups

Scoring Guide:

- Success looks like every group having a functioning circuit and an appropriate poster to share with their peers and others.

EXTENSION ACTIVITIES

Extension Activities:

- As suggested in Lesson 3, students could write an engineering journal article about their circuit design, modeling the journal publishing process.
- Another extension activity would be to really model a scientific conference, and have students both give short individual presentations about one particular aspect of their circuit to begin with, and then transition to the poster session later. In this case, having more community members would be important in order to keep up the interest.

Adaptations:

- Having a pair present each poster at a time to only those pairs and individuals who happen to be walking around should alleviate many of the issues students face when giving presentations, and having the poster and the circuit to refer to should aid students who struggle with vocabulary and memory. If the informality of a poster session is still too much however, individuals could present their poster with just the teacher or one group.
- If completing a Pugh Chart is too much individually, these charts could be completed in pairs. Provide clipboards if students need, and use simple criteria for younger students or more complex weighted criteria for older students.
- If students struggle with the poster design itself, more guidance can be given about what kinds of information need to be included, or physical templates could be printed for them

TEACHER BACKGROUND & RESOURCES

Background Information:

- Hopefully teachers will have experienced a poster session themselves as an undergraduate. If not, it would be very helpful to find an example video online, or to attend one at a local conference or university - either science or engineering focused, or education focused.

Resources:

Some Information about Poster Sessions:

- https://www.nature.com/scitable/nated/topicpage/poster-presentations-13907939
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1876493/
- http://guides.nyu.edu/posters
- https://nau.edu/undergraduate-research/poster-presentation-tips

Background about Pugh Charts

- http://ngss.nsta.org/Resource.aspx?ResourceID=218
- http://www.businessnewsdaily.com/6146-decision-matrix.html
- https://www.sciencebuddies.org/engineering-design-process/best-solution.shtml#keyinfo

Student Handout 4.1: Pugh Chart

Name:_____ Date:_____ Period:_____

Criteria								
Total								

Student Handout 4.1: Pugh Chart

Name:_____ Date:_____ Period:_____