

Lesson Ten: Presenting and Evaluating the Design
Center for Sensorimotor Neural Engineering
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LESSON OVERVIEW

Activity Time: Four 50 minute periods.

Lesson Plan Summary:

In this lesson, students will create a poster to showcase their sensory substitution device design. Students will use Pugh Charts to evaluate the models created by different teams.

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.

Essential Question:

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

Learning Objectives:

Students will know...

- The purpose and use of a Pugh Chart in assessing an engineering design and prototype.
- How a scientific poster session runs and why they are important.

Students will be able to...

- Speak knowledgeably to different groups of people curious about their engineering designs.
- Evaluate a variety of sensory substitution models based on relevant and (weighted) criteria and constraints .

Vocabulary:

- Pugh Chart

Standards Alignment: This lesson addresses the following middle school Next Generation Science Standards Disciplinary Core Ideas (DCIs):

NGSS Middle School Disciplinary Core Ideas

- **MS-ETS1.A Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specifications of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
- **MS-ETS1.B Developing Possible Solutions:** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of the problem.
- **MS-ETS1.C Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.

NGSS Cross-Cutting Concepts

- **Systems and System Models**
- **Structure and Function**
- **Influence of SET on Society and Natural World**

NGSS Science & Engineering Practices

- **SEP:** Asking Questions and Defining Problems
- **SEP:** Constructing Explanations and Designing Solutions
- **SEP:** Developing and Using Models
- **SEP:** Engaging in Argument from Evidence
- **SEP:** Obtaining, Evaluating, and Communicating Information
- **NoS:** Science is a Human Endeavor
- **NoS:** Science Addresses Questions about the Natural and Material World

MATERIALS

Material	Description	Quantity
Posterboards or butcher paper		1 per group
Markers		1 set per group
Rulers		2 per group
<i>Optional:</i> Glue or Tape	To paste on typed text for the poster	1 per group
<i>Student Handout 10.1: Presenting Your Sensory Substitution Device—Presentation Guidelines</i>		1 per student
<i>Student Handout 10.2: Pugh Charts</i>		1 per student
<i>Student Handout 10.3: Presentation Simplified—Your Sensory Substitution Device (Optional)</i>		1 per student (optional)
<i>Student Handout 10.4: Sensory Substitution Device Pugh Chart</i>		1 per student

TEACHER PREPARATION

1. Gather materials for each group to make their poster.
2. Copy handouts as listed in the materials section above.
3. Depending on the level of your students, prepare a template for a rough draft of a poster, or have samples of other types of posters that students can view and evaluate for effectiveness.
4. If you would like a real visual for the Sample Pugh Chart activity, bring three different pairs of shoes (or be ready to ask students to volunteer theirs).
5. For the actual day of presentations, invite other members of the community (teachers, administrators, staff, mentors, parents/guardians) to come observe, ask questions, and give feedback. Alternatively, showcase this engineering design project as part of a Science Fair or Engineering Exhibition event.

PROCEDURE

Engage: Scientific Communication (20 minutes)

1. Ask students: How do scientists and engineers communicate what they've designed and learned to the greater community?
 - (articles/publications, videos, research talks and poster sessions at scientific conferences, informal conversations)
2. Introduce the poster session using *Student Handout 10.1: Presenting Your Sensory Substitution Device—Presentation Guidelines*.

Explore, Explain, Elaborate: Posters (80+ minutes)

3. Students work on the creating their poster. If needed, assign roles such as:
 - End-user: in charge of explaining the purpose and criteria of the project
 - Electrical engineer: in charge of drawing and explaining circuit diagram
 - Computer scientist: in charge of showcasing and explaining the Arduino code
 - Neuroethicist: in charge of explaining the ethical considerations involved
 - Business consultant: in charge of explaining the budgetary constraints and marketing the advantages of their design

Explore, Explain, Elaborate: Pugh Chart (50 minutes)

4. Introduce the idea of Pugh Charts as tools engineers use to evaluate designs based on criteria of different weights. Use *Student Handout 10.2: Pugh Charts* to guide your class through an example about choosing which shoes to buy.
5. As a class, brainstorm criteria that can be used to evaluate the design of the sensory substitution device.
6. In their groups, allow students to choose the criteria that they would like to use on *Student Handout 10.4: Sensory Substitution Device Pugh Chart* (it can be all or just some of the ones that are brainstormed). Groups will then assign weights to each criteria (it may be helpful to pick the same maximum weight). It is encouraged that the groups come up with the weights independent of other groups. This helps with the conversation about how different groups might value one criterion more, therefore potentially resulting in choosing a different “best” design.

Explain, Evaluate: Presentations and Evaluations (50 minutes)

7. Have all students to set up their poster in their groups, and divide each group into two (A and B). (5 min)
8. All the students who are A's will stand by their poster while all the B's will circulate and fill out the Pugh Chart created the day before. Depending on the number of groups, you will have to set up time limits (2 minutes per group) or limit the number of presentations each person visits (only visiting 4 groups instead of all 8, giving each group 4 minutes to present). Students should be rotating through the groups on the teacher's clock so that there are always B students visiting A presentations. (20 min)
9. B students will stand at their poster and the A's will rotate through the presentations and fill out the Pugh Chart. (20 min)
10. Reflect as a class or for homework on what is the best design. If groups have different ideas about what is "best," you can have a class discussion on the merits of each design and how different criteria and weights may have played a role.
11. Possible homework assignment: Based on how different designs scored on the Pugh Chart, is it possible to optimize a design in the class? How might different aspects of different designs be combined to make a new design which might score even higher on all the criteria?

STUDENT ASSESSMENT

Assessment Opportunities: Student knowledge, skills, and concepts for this lesson will be assessed in a number of ways.

- Poster
- Oral presentation
- Effective creation and use of Pugh Chart
- Reflection on how the design can be optimized

Student Metacognition:

- At the bottom of the class Pugh Chart, there is space for students to think about whether they are surprised by what is considered as the best design. This will help students think about the criteria they chose and the weights they used.

Scoring Guide:

- *Teacher Resource 10.1* provides a scoring key for *Student Handout 10.2: Pugh Charts*.

EXTENSION ACTIVITIES

Extension Activities:

- With more time, students can actually design a new sensory substitution device using aspects of various designs they learned from visiting other groups.

Adaptations:

- If there is not enough time to do a formal poster session, you can do a simplified presentation of the designs using *Student Handout 10.3: Presentation Simplified—Your Sensory Substitution Device*.
- Students can make a slideshow presentation or video instead of a poster.

TEACHER BACKGROUND & RESOURCES

Background Information:

Pugh Charts are used in the engineering world, but can really be used in a wide variety of contexts. They are a form of a decision matrix (see Resources section below for more information). Weights are done a little differently in this activity. In many Pugh Charts, scores range from -3 to +3, and each score is multiplied by its corresponding weight. This lesson simplifies the weighting by removing the multiplication step and simply setting a maximum score.

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:

- Decision Matrix: What it is and How to use it
 - <http://www.businessnewsdaily.com/6146-decision-matrix.html>
- Science Buddies: Choose the Best Solution
 - <https://www.sciencebuddies.org/engineering-design-process/best-solution.shtml#keyinfo>
- Jose E. Lugo, University of Notre Dame, Design + Engineering
 - <https://sites.nd.edu/jlugo/2012/09/24/pugh-method-how-to-decide-between-different-designs/>



Student Handout 10.1: Presenting your Sensory Substitution Device—Presentation

Guidelines

Name: _____ Date: _____ Period: _____

In this class, your group will be designing a poster/video/slide show of your design. Your presentation must include large headings, bullet points, and the following sections:

- Design problem: What is name of device and how does it substitute a sense? Who is the user?
- Criteria and Constraints: What requirements did the design need to fulfill and what limitations were there?
- Methods: How did you build your model?
 - Diagrams: What components did you use in your model and how were they connected in a circuit? What was/were the input(s), how was the information processed, and what was/were the output(s)?
 - Circuit Diagram of electronic components
 - Arduino Program - describe the major elements of your program which processes the input to result in an output
- Imagining the actual device: How does the user wear the device? When is it used? Does it have a switch? What materials would make this device even more usable?
- Modifications: What changes did you make and how did they improve your model?
- Ethics: How did you consider ethics in this design?
- Future work: With more time and resources, how might you further improve your design and why?
- Further information: If you completed any of the extension research from the Making It Real handout, you can include that in your presentation

Your poster can (doesn't have to!) have the following layout:

Name of your SSD		
<i>Your names</i>		
Introduction - what need does your SSD seek to address? - how does your SSD address this need? - ?	Draw your final SSD circuit Explain in words how your circuit functions. Be specific but brief.	Conclusion - what are some of the more important changes you made as you worked, and why? - what would be your next steps or improvements now?



Student Handout 10.2: Pugh Charts

Name: _____ Date: _____ Period: _____

Pugh Charts are used to help engineers decide which design solution is “best.” “Best” may have different definitions based on what values different people place on certain criteria. Let’s look at the following example.

You’re choosing between 3 pairs of shoes, and you can only buy one.

1. What are some **criteria** you might consider in choosing the one pair you buy? List them in the first column in the chart below.
2. What value or **weight** do you place on each criterion? For the most important criterion, give a weight of 3. Less important criteria can be given a weight less than 3 (1 for not very important at all, 2 for somewhat important). Two or more criteria can have the same weight (they are of equal importance).
3. Look at each of the three shoes. Give each shoe a **score** for each criteria based on the maximum weight allowed. *For example, one of your criteria is comfort and you gave it a weight of 3. When you try the shoe on, it’s not comfortable at all. You would give it a score of 1 out of 3 for comfort. If you need a shoe for playing basketball and give that a weight of 3, you might give a dress shoe a 1 out of 3 for matching its function.*
4. After going through all the criteria for each shoe, add up the **total** for each shoe. The shoe with the highest total score is the best choice.

Criteria	Weight	Design 1	Design 2	Design 3
Total				

5. Compare your “best” with another person’s or group’s. Why might you have different results? How might this be advantageous or disadvantageous when designing a solution to a problem?



**Student Handout 10.3: Presentation Simplified—
Your Sensory Substitution Device**

Name: _____ Date: _____ Period: _____

What is the name of your device? _____

Who is the user of your device? _____

How will your device help your user? _____

Describe/draw your final sensory substitution device here (or print, tape in, and label a picture).



Student Handout 10.4: Sensory Substitution Device Pugh Chart

Name: _____ Date: _____ Period: _____

Criteria	Weight	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6	Design 7	Design 8
Total									

Reflect: Based on the total score, which design was the “best”? Are you surprised by this? Why or why not?



Teacher Resource 10.1: Pugh Charts Answer Key

Pugh Charts are used to help engineers decide which design solution is “best.” “Best” may have different definitions based on what values different people place on certain criteria. Let’s look at the following example.

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3. Look at each of the three shoes. Give each shoe a **score** for each criteria based on the maximum weight allowed. *For example, one of your criteria is comfort and you gave it a weight of 3. When you try the shoe on, it’s very comfortable. You would give it a score of 3 out of 3 for comfort. If you need a shoe for playing basketball and give that a weight of 3, you might give a dress shoe a 1 out of 3 for matching its function.*
4. After going through all the criteria for each shoe, add up the **total** for each shoe. The shoe with the highest total score is the best choice.

Answers can vary. Below is just an example of how one chart can be filled out.

Criteria	Weight	Design 1	Design 2	Design 3
Functionality	3	3	1	2
Affordability	1	1	0	1
Durability	2	2	2	1
Aesthetics	2	1	1	2
Comfort	2	1	1	1
Total		8 - best	5	7

5. Compare your “best” with another person’s or group’s. Why might you have different results? How might this be advantageous or disadvantageous when designing a solution to a problem?

- Advantage - seeing multiple perspectives; can combine “best” features from different designs and create a new design that incorporates these features; is more realistic representation
- Disadvantage - hard to decide which solution is the one to invest in because everyone’s values are different; have to have longer discussions with other groups about values