Unit: Designing Circuits for Neurodevices

Lesson 4: Productive Uncertainty in Science and Engineering

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LESSON OVERVIEW

Activity Time:

One or two 55 minute class periods.

Lesson Plan Summary:

In this lesson, students will read an article on productive stupidity (uncertainty) and engage in a class discussion on what it means to be productively uncertain in a science classroom. They will end the lesson by filling out a chart that goes over the different combinations of behavior seen in professional science and classroom settings.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- **Productive Uncertainty:** Making advances in scientific research requires that scientists feel comfortable with pushing on the boundaries of their knowledge and living with a feeling of uncertainty. It is okay to not know everything and to have some level of productivity based around this uncertainty. This can lead to deeper meaning and discovery.

Investigative Phenomenon: What does it mean to be comfortable with uncertainty? Scientists, engineers, and researchers continually push on the boundaries of knowledge and practice, inhabiting a world of uncertainty. This search for knowledge, discovery, and solutions to problems is what leads to advances in their fields.

Driving Question:

- What role does productive uncertainty play in the engineering design process and in science?

Learning Objectives:

Students will know…

- That productive uncertainty is an okay and encouraged place to be at during the engineering design process.

Students will be able to…

- Feel confident in their ability to engage in the engineering design process, even if it means that they are not certain.

Vocabulary:

- **Certain:** Knowing with confidence.
- **Engineering:** A discipline that applies math and science to design and build products (devices, structures, tools, machines, etc.) to solve an authentic problem.
- **Productive:** Achieving a desired goal or a result.
- **Productive uncertainty:** Recognizing how little you know about a topic in order to develop important questions to deepen your knowledge. "Being ignorant by choice" in order to push the boundaries of your knowledge.
- **Uncertain:** Not known.
- **Unproductive:** Not achieving a desired goal or a result.

Note: *Definitions were inspired by a variety of website resources, including online dictionaries.*

Next Generation Science Standards:

This lesson does not builds toward a specific NGSS Performance Expectation (PE). Rather, it focuses on elements of the Nature of Science standards connected to the Cross Cutting concepts and practices.

Science is a Way of Knowing:

- Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.
- Science is a unique way of knowing and there are other ways of knowing.
- Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.
- Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.

Scientific Knowledge is Open to Revision in Light of New Evidence

- Scientific explanations can be probabilistic.
- Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.
- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Common Core State Standards

This lesson is aligned to the following CCSS for literacy.

- CCSS.ELA-LITERACY.RST.9-10.7
  Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

- CCSS.ELA-LITERACY.RST.9-10.8
  Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

- CCSS.ELA-LITERACY.RST.9-10.2
  Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

TEACHER PREPARATION

Materials

Material	Description	Quantity

"Stupidity" in Science: A text based discussion	An NWABR lesson on "stupidity" in science. Addresses how it is okay to not know in science and research. https://www.nwabr.org/sites/default/files/2Stupidity_in_Science_SNoSR_1.pdf	See lesson plan URL
Student Handouts	*Student Handout 4.1: Productive Uncertainty* A quadrant chart on the different types of certainty and productivity. Credit: Jeanne Chowning, Fred Hutchinson Cancer Research Center, based on the work of Eve Manz, Boston University.	1/student plus 1 teacher copy
Teacher Resource	*Teacher Resource 4.1: Productive Uncertainty Answer Key*	1

Preparation

1. Go to https://www.nwabr.org/sites/default/files/2Stupidity_in_Science_SNoSR_1.pdf and follow all instructions for running a Socratic Seminar on "Stupidity" in Science.
    a. There are some handouts and an article that will need to be printed.
    b. Unless completing other lessons on the NWABR website, do not complete the *Closure* section of the lesson.

2. Print *Student Handout 4.1* for students and consider making a large-format copy for teacher use in front of class, or else project on screen using document camera.

PROCEDURE

Engage, Explore, Explain, Elaborate (40 – 95 min)

3. Post the following entry task on the board or in whatever format you use in your classroom.
    . *What is the difference between productive and unproductive?*

4. Use the NWABR lesson plan to run the class discussion (see Teacher Preparation section for URL).

Evaluate (10 – 15 min):

5. Pass out *Student Handout 4.1: Productive Uncertainty* to each student.

6. Have students complete each section of the handout with the behaviors they think fit into the different categories.

7. Direct students to discuss in small groups what they wrote and allow them to change or edit anything at this point.

8. Ask for one person per group to share out something they wrote, and write these down on the teacher version for everyone to see.
    a. See *Teacher Handout 4.1* for some ideas of what to put if students are stuck or you are unsure.
9. Post the following exit ticket on the board or in whatever format you use in your classroom.
    a. Which type of practice(s) are best in a science classroom? Why?

STUDENT ASSESSMENT

Assessment Opportunities:

- Teachers can check on student understanding and engagement during the class discussions.
- See NWABR lesson for assessment opportunities.
- The completed chart can be assessed or checked off.

Student Metacognition:

- See the NWABR lesson for opportunities for student metacognition.
- The completed chart can serve as a resource for students to reflect on what is okay and not when it comes to productivity and certainty in science.

Scoring Guide:

- See NWABR lesson for scoring of the discussion.
- The completed chart can be assessed or checked off using the Teacher Handout as a guide (it is by no means a complete and final chart--there are many different and acceptable responses not listed).

EXTENSION ACTIVITIES

Extension Activities:

- Students can be given a writing assignment to reflect further on the reading and the chart that they create.

Adaptations:

- Students can be given teacher marked versions of the text. The article can also be read aloud as a class and gone over by the teacher in front of the class. Modeling of how to closely read an article can be done as well.

- Provide a word bank (see provided vocabulary list in this lesson plan) review it with students before reading to help those students who have a developing vocabulary.

TEACHER BACKGROUND & RESOURCES

Background Information:

- Teachers should understand and have a background with running a Socratic Seminar. See https://www.nwabr.org/teacher-center/ethics-primer#overview for information on how this can be done.

- When teaching about productive uncertainty in science, this STEM Teaching Tool may be helpful:

  Practice Brief #60: Designing 'Productive Uncertainty' into Investigations to Support Meaningful Engagement in Science Practices.
  http://stemteachingtools.org/brief/60

Resources:

Bioethics 101: Reasoning and Justification (Curriculum)
Northwest Association for Biomedical Research
https://www.nwabr.org/teacher-center/ethics-primer#overview

The Social Nature of Scientific Research (Curriculum)
Northwest Association for Biomedical Research
https://www.nwabr.org/teacher-center/nature-scientific-research-0#overview

Citations:

NWABR (2013, September 05). *The Social Nature of Scientific Research*. Retrieved from https://www.nwabr.org/teacher-center/nature-scientific-research-0#overview

Student Handout 4.1: Productive Uncertainty. Credit: Jeanne Chowning, Fred Hutchinson Cancer Research Center, based on the work of Eve Manz, Boston University.

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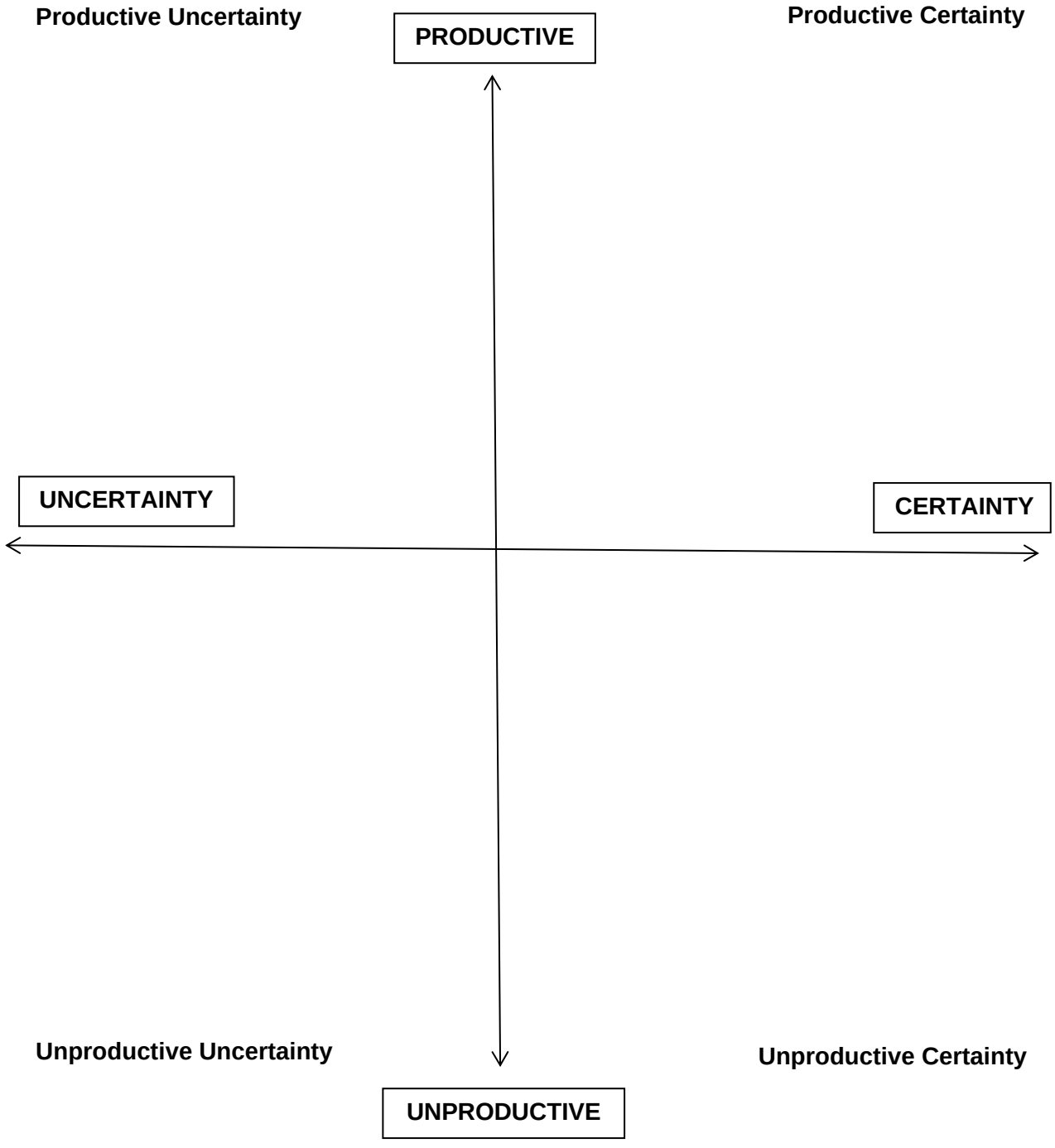
Student Handout 4.1: Productive Uncertainty

Name:_____ Date:_____ Period:_____

Credit: Jeanne Chowning, Fred Hutchinson Cancer Research Center, based on the work of Eve Manz, Boston University.



Teacher Resource 4.1: Productive Uncertainty Answer Key

Credit: Jeanne Chowning, Fred Hutchinson Cancer Research Center, based on the work of Eve Manz, Boston University.