Wired to Respond: The Science of Sensory Systems and AI

(1-2 Weeks)

Authors

Caitlin Berta

Melony August

SUBJECT/GRADE LEVEL

Subject Area: Science

Grade Level: Middle School (grades 6-8)

Materials

- Engage (2 days)
  - Internet enabled device(s)
- Explore (see teacher guide for complete list) (3-4 days)
  - Meterstick
  - Timers
  - Colored Cellophane
  - Colorblind Test Plate (can also just pictures and print them)
  - Tuning forks (can also use a digital sound source-see lesson plan for link)
- Explain (2 days)
  - Paper, pencils
  - crayons/pencil colors/markers
  - iPad
  - Internet access
  - Pipe cleaners (multiple colors)
  - Modeling clay (multiple colors)
  - String or yarn (multiple colors)
  - Cardboard or foam board (as a base)
  - Scissors, glue, tape
  - Markers or labels
  - Any other available craft materials (beads, googly eyes, straws, etc.)
- Elaborate (2-3 Days)
  - Internet enabled device(s)
  - Paper, pencils
  - Note cards
- Evaluate (2-3 Days)
  - Computer access
  - Chart Paper
  - Art Supplies (markers, crayons, pencil colors, paint, glue, scissors, colored paper, white paper, construction paper, paper plates)

STANDARDS

Next Generation Science Standards

- **MS.LS1.8**: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
    - **DCI LS1.D** Information Processing: Each sense receptor responds to different inputs transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.
    - **SEP**: Engaging in argument from evidence
    - **SEP:** Obtaining, evaluating and communicating information.

Mathematics Standards | Common Core State Standards

- **CCSS.Math.Practice.MP1:** Make sense of problems and persevere in solving them.
- **CCSS.Math.Practice.MP3**: Construct viable arguments and critique the reasoning of others.
- **CCSS.Math.Practice.MP4:** Model with Mathematics
- **CCSS.Math.Practice.MP7**: Look for and make use of structure.

English Language Arts Standards | Common Core State

- **CCSS.ELA-LITERACY.RST.6-8.1**
  Cite specific textual evidence to support analysis of science texts.
- **CCSS.ELA-LITERACY.RST.6-8.2**
  Determine the central ideas of a text and summarize key information.
- **CCSS.ELA-LITERACY.WHST.6-8.2**
  Write informative/explanatory texts, including the narration of scientific procedures, experiments, or technical processes.
- **CCSS.ELA-LITERACY.WHST.6-8.7**
  Conduct short research projects to answer a question, drawing on several sources.
- **CCSS.ELA-LITERACY.WHST.6-8.8**
  Gather relevant information from multiple print and digital sources, using search terms effectively.

Technology Standards | ISTE Standards

- **1.1.d** Understand fundamental concepts of how technology works, demonstrate the ability to choose and use current technologies effectively and are adept at thoughtfully exploring emerging technology
- **1.3 a** Use effective research strategies to find resources that support their learning needs, personal interests and creative pursuits.
- **1.3 b** Evaluate the accuracy, validity, bias, origin, and relevance of digital content
- **1.4 C** Develop, test, and refine prototypes as part of a cyclical design process
- **1.5 c** Break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem solving.
- **1.6 c** Use digital tools to visually communicate complex ideas to others.
- **1.7 b** USe collaborative technologies to work with others, including peers, experts or community members to examine issues and problems from multiple viewpoints.

LESSON OBJECTIVE(S)

Students will be able to

- Describe how the nervous system in humans works.
- Describe how humans and machines process sensory information.
- Analyze data related to nervous system diseases and present information on how these diseases affect humans.
- Compare and contrast the human nervous system to artificial intelligence systems.
- Create an artificial intelligence bot and communicate this process with others.

CAREER CONNECTION(S)

Mentor Background:

Dr. Benjamin D. Nye is the Director of Learning Sciences at USC-ICT. Ben's major research interest is to identify best-practices in advanced learning technology, particularly for frontiers such as distributed learning technologies (e.g., cloud-based, device-agnostic) and socially-situated learning (e.g., face-to-face mobile use). His research interests include modular intelligent tutoring system (ITS) designs, modeling social learning and memes, cognitive agents, and educational tools for the developing world and low-resource/low-income contexts. He received his Ph.D. in Systems Engineering from the University of Pennsylvania in 2011. Ben's research tries to remove barriers to development and adoption of ITS so that they can reach larger numbers of learners, which has traditionally been a major roadblock for these highly-effective interventions. He also believes that the future of learning science depends on large, sustainable platforms with many users, where efficient sampling techniques can be used to drive new designs for experiments.

STEM Careers: Learning Scientist, Artificial Intelligence researcher, Human Computer Interaction specialist, EdTech Product Designer, Data Scientist, Systems Engineer

ENGAGEMENT

Brief Description: In this stage students will be engaged twice! Once for the nervous system, the second for artificial intelligence. In the first part, students will be introduced to the basics of the human body's nervous system. Students will view a PBS video, Nervous System Science Trek and play a Nervous System Trivia Game with information from the video. For the second part, students will model how artificial intelligence neural networks function and design their own AI powered car.

Nervous System: Procedures:

1. Divide the class into groups of 2-4 students. (This can be done before or after the video.)
2. Tell students that they will play a trivia game in teams at the end of the video.
3. Instruct students to carefully observe the video while remembering or taking notes from the information. (with teammates or alone)
4. Display the Nervous System: Science Trek video for students.
5. Move groups of students to different areas in the classroom.

6. Instruct students on the rules of the game, then read the Nervous System: Science Trek Video Quiz Questions one at a time for each team.
7. Game directions:
    a. Work as a team to answer the questions. Discuss answers to each question with your teammates before answering. Each question will be read twice.
    b. Wait for your teacher to call your group before giving the answer. Each group will have a chance to answer successive questions first. (Team 1 can try question 1, Team 2 can try question 1 if team 1 does not answer correctly. If team 1 answers correctly, question 2 will be read for team 2, etc.)
    c. If your team answers your question correctly, you will be given a point.
    d. If your team does not answer your question correctly, the next team in line, called by your teacher, will have a chance to answer the question.
    e. The team with the most points, wins.
        i. The teacher may want to add a rule for blurting answers without team discussion or before the team is called.
        ii. The winning team can line up first to leave class at the bell or for lunch (prizes are not necessary).
        iii. These questions can also be placed into the Kahoot or Blooket platform and played in individual or team mode.
8. Introduce lesson vocabulary in the manner that is appropriate for the class. (word wall, my turn your turn, handout, google slides, etc.)

Artificial Intelligence: Artificial Intelligence in many ways mimics the systems of our nervous system. From neural networks that gather and communicate information to the computer system. In this activity, students will create a human model of a neural network as well as explore how driverless cars operate.

Procedures: Artificial Intelligence:
Neural Network Artificial Intelligence Activities (instructions and cards)

1. Build a human Neural Network
    a. Assign your students roles
        i. 4-6 Input Neurons
        ii. 2-4 Hidden Layer Neurons
        iii. One Output Neuron (Facing away from the input neurons)
    b. Arrange students into rows to mimic a neural network (see image in linked document above)
    c. Connect students using yarn or string to simulate these connections.
    d. The teacher will display a picture or description of an animal (Ex. cat, dog, horse). (cards are in linked document above)
        i. Input neurons will raise the cards that match features in the pictures.
        ii. Hidden Neurons will "process" this information by adding up the votes or scores (how many cards are raised)
        iii. The Output Neurons guess the animal)
2. Explain: "Just like you learn from mistakes, neural networks do too. If you guessed wrong, you'll give feedback to help adjust how much weight each input should have.

a. If the guess was wrong, give feedback
    i. Inputs that helped = + 1 token
    ii. Inputs that misled = - 1
3. Repeat steps 1 and 2 for a different animals and different traits
    a. Do this 2-3 times.
    b. Students should notice guesses improving

Self Driving Cars

1. Begin by asking students "What senses do humans need to drive a car?"
    a. Wait for student responses and list them on the board.
2. Ask students: What do you think that a self-driving car uses instead?
    a. Make a list of what they think.
    b. Show students a quick video of a Waymo car driving by itself.
        i. Ask students to make a list of any sensors or information they see in the video that the car may use to drive.
            1. Camera, radar, lidar, GPS, Microphones"
        ii. Ask students to think about how a car like this could be trained and write these ideas down. They will be revisited later in the unit.
    c. Students will make a drawing of a driverless car with the sensors they would incorporate for the following characteristics
        i. Safety
        ii. Navigation
        iii. Proximity sensors
        iv. Any other sensors they want to include.
    d. Ask students to explain what each of these sensors do and why they need to be included. Student drawings and explanations can be displayed in the classroom.

EXPLORATION

Brief Description: Students will explore and apply the knowledge gained during the engage portion of the unit to apply this to how the human body, other animals and Artificial Intelligence agents react to stimulus. Students will gather ideas about these concepts and model their understanding in a variety of ways. Many of these assignments will be hands-on and experiential.

Procedures:

Prior Knowledge Activation

- Students will be placed in groups to model on a piece of paper what the nervous system does and how it functions. Students will use this handout for this activity.

Sensory Stations

Task card/instruction Student handout Teacher Guide

Before beginning these activities, group students in teams of 2-3. This will make the stations work the best. It is suggested that you have at least 2 sets of each station set up in your classroom to ensure that things move smoothly. Each station is estimated to take 20-30 minutes. Depending on your schedule,

you should be able to have students complete 2 stations a day. The entire activity should take 2-3 days to finish.

- **Station 1: Reaction Time**
  - At this station students will test their reaction time by holding a meterstick and timing how long it takes them to catch it as well as measuring how far the meterstick dropped before they caught it.
  - Students will calculate their average time to catch the meterstick.
  - Students can also compare their reaction times with a regular ruler by repeating the same process.
- **Station 2: Color and Light**
  - At this station, students will explore how we sense color. They will engage in a simple colorblindness "test" to see how their eyes sense colors. They will also learn about the anatomy of the eye and how we see colors. The focus will be on inputs and outputs.
  - Students will have different colored papers and different colored filters. They will play around with color mixing and what happens when they put certain colors together with how they sense color.
- **Station 3: Sound**
  - At this station students will explore the different ways we perceive sound with different media using tuning forks.
  - Students will also learn about the ways in which we hear information and how signals are transmitted to our brains for us to perceive sound.
- **Station 4: Touch Sensitivity**
  - Students will examine texture and our sense of touch at this station.
  - Using various objects with different textures, students will try to guess just by what they feel. (blindfolds are optional for this activity)
  - Students will also engage in a touch discrimination test where they will use a paper clip on different parts of the body to see if they can feel one or two points of the testing device.
- **Station 5: Different Species, different senses (Organism cards)**
  - Students will compare and contrast three different species and the way in which they process information and the structures that they use for processing information.
    - Human
    - Aplysia
    - Pit Viper
- **Station 6: How Machines Sense and Learn (classification cards)**
  - Students will model machine learning and create an algorithm at this station.
    - First they will use cards to decide on a classification system. They will then test this system using different cards and analyzing what they did.

- Then they will use google QuickDraw to look at how a real system was trained for image recognition. THey will analyze this data set and compare/contrast information.

Explore Assessment: Students will complete this reflective exit ticket for what they experienced in these stations. They are designed for you to pick and choose the questions you want to ask in the format you choose.

EXPLANATION

Brief Description: During the Explain stage of the lesson, students will take a deeper dive into learning about the Nervous system. We will set aside our knowledge of AI systems for now, but we will examine the nervous system in more depth. Students will create a model of the nervous system, define and work with the vocabulary and assess their knowledge of the nervous system.

Procedures:

- Students will use lesson vocabulary to explain unit key words by creating and presenting an interactive digital game using the Kahoot or Blooket platform. (Both platforms require a minimum free account.) Students will clarify and reinforce their understanding of terms by creating questions and accurate definitions.
    - **Review Vocabulary Terms:** Students will review vocabulary terms presented in the engage phase of the lesson given through notes, text, or handouts to refresh meaning and understanding
    - **Define Each Word:** Students will write a simple, accurate definition for each term.
    - **Plan Questions:** create 1 multiple choice question or true/false statement for each word ensuring that each question is understandable and is correct.
    - **Choose Your Platform:** Decide if you'll use Kahoot or Blooket or another teacher-approved tool. Login and create your new game or quiz. Be sure to make your game or quiz public so that your classmates can discover or find your game or quiz.
    - **Build Your Game:** Type in the questions and answer options. Add pictures or emojis to make the game more engaging to your classmates. Check for spelling and correctness before saving each question.
    - **Test and Preview:** Test your game before you share with the class. Correct any errors before sharing.

- Students will demonstrate their understanding of the human nervous system by designing and constructing a three-dimensional anatomical model that illustrates the key components and structure of the nervous system. Students can select different colors, textures, or extra items like adding a body outline to their project to encourage individuality.
    - **Research and Plan**: Begin by reviewing the major components of the nervous system—brain, spinal cord, and peripheral nerves. Students should sketch a basic layout of their model on paper before starting. Allow students to use pictures from engage or explore

or images from the internet to find a model of the nervous system that includes the brain that shows the cerebrum, cerebellum, and brainstem, the spinal cord and nerves.
    - **Build the Brain**: Use modeling clay to sculpt the brain. Include distinct regions such as the cerebrum, cerebellum, and brainstem. Choose different clay colors to represent each part, and place the brain at the top of the base. Encourage students to include gyri and sulci to model the texture of the brain.
    - **Construct the Spinal Cord**: Attach different colored pipe cleaners or clay to show the different sections of the spinal cord extending downward from the brain to represent the spinal cord. 5 Different colors should represent the cervical, thoracic, lumbar, sacral, and coccyx regions of the spines. Students should anchor it firmly to the model firmly to the cardboard or styrofoam board.
    - **Add Peripheral Nerves**: Using pipe cleaners, string, or yarn, students should extend the appropriate numbers of peripheral nerve pairs from each section of the spinal cord to represent peripheral nerves branching out from the spinal cord. Arrange them to spread outward like tree branches, showing how nerves reach out to different parts of the body.
    - **Label Key Parts**: Create small labels to identify the brain, spinal cord, and key nerve groups. Labels can be attached with toothpicks or glued beside components. Components on labels must be spelled correctly.

- OPTIONAL: Students will then complete this activity (Circle of Nerves). They will collect data on how long reactions take and then compare this to how the body responds in baseball.

Draw a representation of a neuron

Using paper, pencils, crayons and/ or pencil colors draw and label the parts of a nerve cell that include the following. Each part must have a name as well as function on each label.

- Cell body
- Nucleus
- Dendrite
- Axon
- Myelin Sheath
- Nodes of Ranvier

ELABORATE

Brief Description: Students will assume the role of a researcher and explore various nervous system diseases by utilizing an AI chatbot designed to help them identify the disease based on the provided symptoms. Students will communicate this information to their peers via a poster or presentation.

Procedures:

Researching Common Diseases of the Nervous System

Students will research and present information on common diseases of the nervous system, including their causes, symptoms, treatments, a famous person affected by the disease, and its impacts on individuals and society.

Instructions:

- Students will be given the symptoms of the common disease of the nervous system from the list below (Print and laminate these cards for each group of students.)

    - Alzheimer's disease
    - Parkinson's disease
    - Multiple Sclerosis
    - Meningitis
    - Stroke
    - Huntington's Disease
    - Muscular Dystrophy
    - Spina Bifida

Research the chosen disease using a chatbot (Created in Magic School, will require a log in) (if Magic School is not an option, you can use Gemini or ChatGPT using a prompt similar to the one below: and other resources. Use the following as a guide to help you structure your report.

- *For using the chatbot, you will need to have a magic school log in to be able to access and use. You could also have students use google Gemini or ChatGPT or just Google. The idea is that they use resources to research what the symptoms relate to.*
    - *Sample prompt. Imagine you are a doctor helping a younger physician with a diagnosis. We will give you the symptoms and you will help guide them to the disease with questions. The options for diseases include: Alzheimer's, Parkinson's, Multiple Sclerosis, Meningitis, Stroke, Huntington's disease, Muscular Dystrophy and Spina Bifida. The younger physician is a middle school student, so please keep answers appropriate for their age level.*

Digital Representation

- Create a multimedia presentation
    - Develop a multimedia presentation using PowerPoint, Google Slides, or another teacher-approved platform.
    - Include key points from the research report, using visuals such as images, charts, and videos to enhance understanding.
        - Required information:
            - Introduction: Brief overview of the nervous system and the importance of understanding its diseases.
            - Disease Description: Detailed information about the chosen disease, including causes, symptoms, diagnosis, prognoses, and treatments.
            - Impact: Discuss the impact of the disease on individuals, families, and society.
            - Neurological Disorders in the Spotlight: Research a famous person with your chosen disorder. Give a brief synopsis of the person. (What he or she does for a living, how the disorder has affected the person, is the person still active in their profession.)
            - Conclusion: Summarize key points and reflect on the importance of research in combating these diseases.
            - Include a list of all sources used
    - Be prepared to present the slides to the class, explaining the disease and answering questions from the student audience or the teacher.

EVALUATION

Brief Description: Students will put together a final presentation of their AI Machines and demonstrate their understanding of how Neural networks and machine learning work. Students should use all of their knowledge from all stages of their lesson plans to make this presentation.

Procedures:

1. Students will investigate previously created bots using Teachable Machine. They will use this beginning research to begin brainstorming what sort of bots they can create using Teachable Machine. Students must create a bot that is different from the ones they interact with.
    a. Teachable Machine Presentation
2. Students will create a presentation (handout with rubric for presentation) of their experience creating their bot. This presentation must include the following elements:
    a. Explanation of their method in creating their Teachable Machine Bot
    b. Video or screenshots of their bot in action
    c. At least 2 slides connecting their teachable machine to the following topics
        i. Neural Networks
        ii. Human Nervous System
        iii. How machines sense and learn.

REFERENCES

- Teachable Machine
- AiEdu
- PBS Science Trek: Senses
- Google Quick Draw
- PBS Science Trek: Nervous System
- Nervous System: Science Trek Video Quiz Questions
- Nervous System Vocabulary