Visual Processing 5E STEM Unit

(8 or 9 - 45 minute class blocks)

Authors

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SUBJECT/GRADE LEVEL

Subject Area: Science

Grade Level: Middle School

**Note: This lesson can be used in its entirety or just specific sections. It can also be easily adapted for High School Biology.

Materials

- **Gorilla Illusion Experiment**
  - Video projector, student handout
- **Cow Eye Dissection**
  - Preserved cow eyes, student handout, pre-lab, video projector, dissection kit (including pointed scissors, forceps, probes, blunt scissors), goggles, aprons, and gloves.
- **Optic Nerve/Nervous System Study**
  - Video player, student handout, paper, colored pencils for mind mapping the brain, rubric handout for assessing
- **Reaction Time Game with Data Collection**
  - Difficulty level dependent, can use pre-programmed games on personal devices or have students design and code a game to collect data, rubric handout for assessing
- **Data Analysis and Scientific Writing**
  - Word processing program to write a scientific lab report or for middle school fill out a C-E-R student handout, rubric handout for assessing

STANDARDS

Next Generation Science Standards

- MS-LS1-3
- MS-LS1-8

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.8.SPA.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive and negative association, linear association and nonlinear association.
- CCSS.MATH.CONTENT.8.SPA.2 Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.
- CCSS.MATH.CONTENT.8.F.B.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

LESSON OBJECTIVE(S)

Engage: Gorilla Illusion Experiment

-Students will participate in a short in class experiment demonstrating “inattentional blindness” where students think they see what is going on in a video but miss key elements due to inattentional blindness.

Exploration: Cow Eye Dissection

-Students will be able to identify and describe the major parts of the eye and their role in the process of vision, comparing and contrasting the structure and function of the cow eye with the human eye through direct observation.

Explanation: Optic Nerve/Nervous System Study

-Students will be able to model/map the pathway of the optic nerve from the eye to the brain and explain its role in transmitting visual information.

-Students will be able to discuss how the optic nerve integrates with other sensory and motor pathways of the nervous system, emphasizing its importance in coordinating vision with other body functions.

-Students will be able to analyze the interaction of multiple body systems.

Elaborate: Reaction Time Game with Data Collection

-Students will be able to collect and record their reaction time data through the classroom game designed to measure how quickly they respond to visual stimuli.

-Students will be able to design and code a reaction time game using a programming language (e.g., Scratch or Python), collecting data from multiple users.

Evaluation: Data Analysis and Scientific Writing

-Students will be able to use statistical methods (mean, median, mode) to analyze their reaction time data and interpret the results to identify patterns or trends.

-Students will be able to create graphs to visually represent their own reaction time data, and compare their results with classmates to understand variability and distribution.

-Students will be able to gather reaction time data from multiple users, analyze the results in written form, and present their findings through a written report or oral/digital presentation.

CAREER CONNECTION(S)

Mentor Background: Dr. Chloe Callahan-Flintoft

Dr. Callahan-Flintoft's work focuses on Aided Target Recognition (AiTR) where a computer vision system displays highlights or places salient markers in Soldier's heads-up display to alert them to potential threats. Our challenge is to design systems that improve performance (e.g. make Soldiers faster and more accurate) without inducing new errors (e.g. creating distracting, cluttered displays or making Soldiers overly reliant on AiTR such that they are unable to process a scene for themselves). Educators on this project will be tasked with analyzing data from experiments that explore how AiTR affects human visual processing so we can navigate this large, complicated space and make design recommendations.

https://www.army.mil/article/231344/army_scientist_enhances_future_combat_wearable_technology

STEM Careers:

AI Engineer

https://aidegreeguide.com/military-service-member-and-veteran-civilian-careers-in-ai/

Biomedical Engineer

https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm#:~:text=systems%2C%20and%20software.-,Duties,technical%20support%20for%20biomedical%20equipment

Data Engineer

https://www.springboard.com/blog/data-science/careers-in-ai/#data-scientist

ENGAGEMENT

Brief Description: To create a high level of engagement in learning about the visual system and how it integrates into the brain allowing for information to be processed students will experience an "illusion"

or magic where they have to count the number of balls being passed in a video. What they will not expect is that a life size gorilla will walk through the video.

Objectives: Students will participate in a short in class experiment demonstrating "inattentional blindness" where students think they see what is going on in a video but miss key elements due to inattentional blindness.

Procedures:
Time Frame: 20 min

Background Information: The brain and visual systems are highly interconnected. Researchers have long been interested in how the brain processes information, including what information is captured and retained vs. what information is dismissed. In this activity the students will participate in an experiment originally conducted by psychologists Christopher Chabris and Daniel Simons where individuals watch 6 kids toss a basketball back and forth. The viewer (or students) are asked to count the number of times the students pass the basketball. While they are watching the students pass the ball, a large gorilla will walk through the scene. Most people do not see the gorilla because they are so intent on counting the balls being tossed. This is called inattentional blindness.

Supplies: a projector or promethean board to project the video, and students should have a pencil and sheet of paper.

Teacher actions: The teacher will introduce the lesson, building excitement by telling the kids that they are going to participate in a quick "magical experiment" - DO NOT say anything about the gorilla. The teacher will ask the students to watch the quick clip and count the number of times the students in **white shirts** pass the basketball. As soon as the first clip stops, stop the video! Ask the students how many times the ball was passed? Did they notice anything different? The teacher will explain that there was a gorilla in the video, along with the curtain changing color and a person leaving the scene. Most students will not even notice these changes. The teacher will play the rest of the video which explains how people can miss something glaringly obvious when they are focused on another task.

Student actions: Students will watch the clip and attempt to count the number of times the ball is passed by the kids in the white t-shirts.

Opportunities for formative assessment: The Invisible Gorilla SE and TE KEY

A formative assignment to be used after the experiment to reflect on the experience.

Hyperlinks: The experiment with a brief explanation - The Monkey Business Illusion

The detailed explanation - The Invisible Gorilla (featuring Daniel Simons) (EMMY Winner)

Adaptations for individual learners and/or virtual options: Spanish Version - Spanish Copy of The Invisible Gorilla SE To see other optical illusions - https://michaelbach.de/ot/

This is a great virtual component of this lesson as it could be shared over a zoom or google meet easily.

EXPLORATION

Brief Description: Students will participate in a dissection of a cow eye wet-lab, including a pre-lab to understand the anatomy of the eye and how the eye integrates into the human systems.

Objectives:
-Students will be able to identify and describe the major parts of the eye and their role in the process of vision, comparing and contrasting the structure and function of the cow eye with the human eye through direct observation.

Procedures:
Time Frame: 2 - 45 minute class periods

Background Information: Cow eyes are typical dissection specimens used in the lab to study eye anatomy because they are structurally and functionally similar to human eyes. Students will explore the external and internal anatomy, learning how structures work together to create images from incoming light.

Supplies: Preserved Cow Eye, Dissecting Tray, Pointed scissors, Probe, Blunt scissors, Forceps, and Scalpel (not necessary, especially if using pointed scissors). These supplies are needed for each pair of students. Each student will need the following: Lab Handout, Pencil, and appropriate personal protective equipment including gloves, goggles, and lab apron or lab coat.

Teacher actions: During the first class, the teacher will introduce the cow eye dissection. Students will review the slide show with the teacher and complete the pre-lab. The pre-lab includes learning how to identify the major structures for the eye. Students will also be able to identify potential safety hazards in this lab, as well as safe handling of sharp dissection tools, wearing gloves and eye protection.

Student actions: Students will participate in the teacher's powerpoint lesson and complete the pre-lab handout, preparing them for the next class.

Opportunities for formative assessment: Students will be assessed formatively through the completion of the pre-lab work. Students will submit a post lab summative assessment at the end of the dissection.

Hyperlinks:

Focusing Light Gizmos and Cow Eye Dissection Pre-lab , The Eye Lecture

Copy of Cow Eye Dissection Handout only SE , Cow's Eye Dissection I Exploratorium

Adaptations for individual learners and/or virtual options: Some students may feel uncomfortable with completing a cow eye dissection for reasons beyond nerves. It's important to take into account that many cultures do not believe in dissection or are uncomfortable with the fact that it is a cow. These students can still complete the pre-lab and either be only an observer with another student if they feel comfortable or they may simply watch the Exploratorium video to still be able to experience the lab. This can be used for a virtual lesson as well.

EXPLANATION

Brief Description: Students will understand how the optic nerve and brain work together to create visual perceptions by watching a documentary and creating a mind map that models the transfer of signals from the eye to the brain. Students can doodle, take notes, research during the documentary then share final works through presentations or gallery walks.

Objectives:

-Students will model/map the pathway of the optic nerve from the eye to the brain and explain its role in transmitting visual information

-Students will discuss how the optic nerve integrates with other sensory and motor pathways of the nervous system, emphasizing its importance in coordinating vision with other body functions

-Students will participate in class discussions analyzing the interaction of multiple body systems.

Procedures:

Time Frame: 2 - 45 minute class periods (if teacher chooses to show entire documentary-55 minutes)

Background Information: Students will view a 55-minute documentary exploring the intricate relationship between the eye and brain in constructing our reality and forming perceptions. During the documentary, students may take brief notes or create quick sketches to capture key points without detracting from their viewing experience. After the documentary, students will consolidate their understanding by creating detailed mind maps. These visual representations will include all the information they have retained and any additional research they have conducted. Finally, students will present their mind maps to their peers, facilitating a collaborative exchange of knowledge and insights.

Supplies: Device for projecting the documentary or allowing individual viewing by students, as preferred by the teacher, sketch paper or any suitable paper for drawing, colored pencils for detailed illustrations, if desired.

Your Brain: Perception Deception | Full Documentary | NOVA | PBS

Teacher actions: Create your own mind map in advance to establish clear expectations for students' work and to assist with providing guidance as needed. Utilize the following guiding questions to prompt students during the finalization of their mind maps after the documentary viewing.

Guiding questions for PBS documentary and Mind Mapping

Student actions: Students will watch the 55-minute documentary on the relationship between the eye and brain in forming perceptions. During the viewing, they will take brief notes or create quick sketches to capture important concepts. After the documentary, students will combine the information by creating detailed mind maps, incorporating additional research as needed, and will then share and discuss their visual representations with their peers.

Opportunities for formative assessment: Students' performance can be assessed using a rubric that evaluates their engagement during the documentary, the content and organization of their mind maps, and the clarity and thoroughness of their explanations to their peers.

Formative Assessment: Optic Nerve and Brain Perception Mind Map

Hyperlinks: Guiding questions for PBS documentary and Mind Mapping

General mind mapping information

Your Brain: Perception Deception | Full Documentary | NOVA | PBS

Formative Assessment: Optic Nerve and Brain Perception Mind Map

https://www.mural.co/templates/mind-map

Adaptations for individual learners and/or virtual options:

Teachers can offer learners a structured graphic organizer for organizing their thoughts, complete with sentence starters to guide their writing and maintain focus. Students may opt to emphasize writing over drawing by creating lists or using bullet points to outline information. They can also utilize online resources, such as canva, google sites, google slides or https://www.mural.co/templates/mind-map, to enrich their understanding. Additionally, students have the option to collaborate in groups or create detailed, labeled 3D models as part of their exploration and representation of the topic.

ELABORATE

Brief Description: Students will design, code, and test a simple reaction time game using a block-based or text-based programming language (e.g., Scratch or Python). They will collect and analyze reaction time data from multiple trials, developing an understanding of basic programming concepts, data collection methods, and statistical analysis. Through this activity, students will enhance their problem-solving skills, creativity, and ability to interpret and present data effectively.

Objectives:

-Students will collect and record their reaction time data through the classroom game designed to measure how quickly they respond to visual stimuli.
-Students will design and code a reaction time game using a programming language (e.g., Scratch or Python), collecting data from multiple users.

Procedures:

Time Frame: 2-3 45 minute class periods

Background Information: Understanding reaction time is essential for various real-world applications, from driving safety to athletic performance to safety and military exercises. By coding a reaction time game, students will apply programming skills to create an interactive project that measures how quickly a person responds to a stimulus. They will collect multiple trials of data to be analyzed during the evaluation portion.

Supplies: Devices; notebooks for notes; graph paper or Google Docs/Sheets for data collection and note-taking; access to coding software such as Scratch (available for free at scratch.mit.edu, students will need to set up an account).

Teacher actions: Begin by introducing the concept of reaction time and its significance in various real-world applications. Refer back to previous activities of perception and how technology can help

humans improve visual alertness in safety situations. Demonstrate a sample reaction time game to provide students with a clear understanding of the project goal.

Easy reaction time games:

https://www.airportscannergame.com/ https://humanbenchmark.com/tests/reactiontime

https://www.justpark.com/creative/reaction-time-test/

Guide students through the setup of their coding environment, ensuring each pair or group can access and navigate the chosen platform, such as Scratch. Provide support and answer questions as needed.

Helpful tutorial for your desired systems:

Scratch Tutorial | Human Benchmark Reaction Time Test on Scratch

Code.org - Learn Making Games - Reaction Game Microbit Reaction Time Pt1

Microbit Reaction Time Pt2 https://projects.raspberrypi.org/en/projects/astronaut-reaction-times

After coding, explain the data collection procedure, emphasizing the importance of accurate recording. Oversee the data collection process, ensuring that students adhere to the protocol and accurately enter data into their spreadsheets.

Student actions: Students will engage in an introduction to reaction time, follow a coding demonstration, and work in pairs or small groups to code, test, and debug their reaction time game. Students will collect reaction time data from peers, record it in a spreadsheet, and begin initial data analysis. Students can periodically participate in gallery walks to learn from peer groups, share successful strategies, and discuss challenges.

Opportunities for formative assessment: Coding and Data Collection Rubrics

Hyperlinks: Coding and Data Collection Rubrics MakeCode for micro:bit - Reaction Time Game

Scratch Tutorial | Human Benchmark Reaction Time Test on Scratch

Code.org - Learn Making Games - Reaction Game Microbit Reaction Time Pt1

Microbit Reaction Time Pt2 https://projects.raspberrypi.org/en/projects/astronaut-reaction-times

https://www.airportscannergame.com/ https://humanbenchmark.com/tests/reactiontime

https://www.justpark.com/creative/reaction-time-test/

Adaptations for individual learners and/or virtual options:

-Advance the gaming portion with circuit boards coded by scratch; see tutorial:

MakeCode for micro:bit - Reaction Time Game

-Simplify the gaming scenario and save time by just playing games and collecting data listed in teacher directions instead of coding a new game.

- https://humanbenchmark.com/ Use the human benchmark website to create a data set of multiple trials tracking student reactions to various stimuli. This can be done remotely.

EVALUATION

Brief Description: Students will conclude this unit by working through a C-E-R analysis. As part of the C-E-R they will analyze the data they collected in the last section and how that data supports or does not support their scientific claim. Students will use the C-E-R analysis to create a poster presentation or slide show to present their findings to their classmates.

Objectives:

-Students will use statistical methods (mean, median, mode) to analyze their reaction time data and interpret the results to identify patterns or trends.

-Students will create graphs to visually represent their own reaction time data, and compare their results with classmates to understand variability and distribution.

-Students will gather reaction time data from multiple users, analyze the results in written form, and present their findings through a written report or oral/digital presentation.

Procedures:

Time Frame: 2 - 45 minute class periods

Background Information: Students will use statistical methods such as mean, median, and mode to analyze their reaction time data. By interpreting the results, they will be able to identify patterns and trends within the data.

Supplies: paper, pencil, calculator, computer, google sheets,

Teacher actions: On the final day, introduce basic data analysis techniques and guide students through calculating averages and creating visual representations of their data. This may include introducing basic usage of google sheets data entry. Teachers will introduce the C-E-R Graphic organizer and how they create an appropriate analysis. Teachers will lead a discussion on how data may support (or not support) a claim and how to write a conclusion even when the data does not support the claim. This may be due to the collection methods, sources of error or limited amount of data.

Once students finish with the C-E-R teachers will facilitate students' preparation of their presentations, ensuring they include key findings and insights from their analysis. These presentations may be done through a slide show or with posters and a gallery walk. Conclude by assessing the presentations, providing constructive feedback, and encouraging reflection on the learning experience.

Student actions: Students will work together to complete the C-E-R Graphic organizer and use statistical methods such as mean, median, and mode to analyze their reaction time data from multiple users. Students will also create graphs to visually represent their own reaction time data. These graphs will provide a clear picture of the distribution of reaction times. By comparing their results with those of their classmates, students will gain a deeper understanding of variability among individuals. By interpreting the results, they will be able to identify patterns and trends within the data.

By analyzing the data and comparing it to their hypotheses, students will provide evidence to support their findings. Through the process of reasoning, students will draw conclusions about the patterns and

trends observed in the reaction time data. Students will present their findings through a written report or an oral/digital presentation. This will allow them to communicate their analysis and conclusions effectively. By engaging in this project, students will not only enhance their understanding of statistical methods but also develop critical thinking skills as they investigate reaction time and its implications.

Opportunities for formative assessment:

Reaction Time CER Student Graphic Organizer and Rubric.docx

Hyperlinks: Reaction Time CER Student Graphic Organizer and Rubric.docx

Adaptations for individual learners and/or virtual options:

- https://humanbenchmark.com/ Use the human benchmark website to create a data set of multiple trials tracking student reactions to various stimuli. This was listed above as a remote activity. Once the student has collected a data set, they can then complete the C-E-R worksheet and slideshow to be graded by the teacher.

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