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| **Fellow Name: Andrew Fisher** | **Contact Info:** [**fisheraw@mail.uc.edu**](mailto:fisheraw@mail.uc.edu) | **Date: 12/17/14** |
| **Teacher Name:**  **Eryn Ruder / Deon Edwards** | **School Name:**  **Northwest HS / Aiken HS** | **Grade and Class:**  **11th ~ 12th Anatomy and Phys.**  **9th ~ 10th Engineering Basics** |

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| **Activity Title:** | **Engineering Solutions Using Nature’s Template** |
| **Estimated Activity Duration:** | **10 minute Preparation + 45 minute Lecture + 45 minute Activity** |

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| **Setting:** | **Classroom with group/lab tables** |

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| **Activity Objectives:** |

The student will be able to:

1. Identify the parts of a camera that correspond to the parts of a human eye.
2. Trace the flow of light through a camera and how it is absorbed in the digital array.
3. Name inventions that mimic the human form.
4. Design and build model finger from common craft items.

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| **Activity Guiding Questions:** |

1. What are the components of an eye?
2. What are the components of a camera?
3. What do the human eye and the camera have in common?
4. What inventions have mimicked the human anatomy?
5. How do engineers use the human form to influence their designs?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☒ Asking questions (for science) and defining problems (for engineering) | ☒ Patterns |
| ☒ Developing and using models | ☐ Cause and effect |
| ☒ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☒ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☐ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☒ Demonstrating Science Knowledge **(D)** |
| ☒ Interpreting and Communicating Science Concepts **(C)** |
| ☒ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

* **From Northwest School District standards for Anatomy and Physiology.** 
  + **Unit #2 – Support and Movement**
    - **Students will be able to…**
      * **Describe the functions of the human skeleton**
      * **Describe the macroscopic and microscopic structures of the long bone and their functions**
      * **Describe the structure of a skeletal muscle both micro and macroscopically**
      * **Define and identify muscles origins and insertions**
      * **Describe muscle movements and provide examples**
  + **Unit #3 – Integration and Coordination**
    - **Students will be able to…**
      * **Identify structures and functions of the eye**

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| **Materials**: |

1. Pre-test/Post-test 
2. PowerPoint Presentation 
3. Access to a film developer
   1. Research what type of film you can use before activity.
   2. I will be using 4”x5” film
   3. Note: very advanced preplanning may be required if you are trying to develop the film before your activity takes place. You may want to develop the film yourself.
4. Student Instruction for activity 
5. Instructor Advanced Preparation

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| **Teacher Advance Preparation:** |

The COFSP Fellow will need to buy or construct a pinhole camera. I will be constructing mine so I can take pictures of the progress, allowing students to better understand the components of the camera. This camera should be tested in light setting similar to the classroom setting, this will allow the COFSP Fellow to know how much exposure time is needed.

Research what type of film local developers can process.

The class may want to create a banner or poster to hold up in picture.

Prior to this activity the students should have some basic knowledge of the contents of a human eye and how it works. This activity does not explain the contents of the eye, it applies the knowledge of the contents of the eye.

The crafting materials will need to be prepared. I will be using popsicle sticks as the main component of the finger (stand in for bone). I have pre drilled four evenly spaced holes in each popsicle stick to allow a small piece of skewer to be placed through two popsicle sticks and thus create a joint. Also, each group of two or three students will be given a kit of components, these kits will need to be preassembled. All preparation for this activity is outlined in attached document titled, Finger Activity Preparation.

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| **Activity Procedures:** |

Day 1: Activity Preparation

Before taking the picture, the first slide of the power point should be displayed on the board. This is used to show students what is expected when they are drawing a light diagram. This is used on the pretest. Include a little description of what happens when light moves through a periscope.

The class will pose for a class picture inside the classroom or near the school outside. It will take about five minutes to setup the camera, pose and take the picture.

After the class poses for the picture, have them take the pre-test. This will give the opportunity to read the pre-test and include extra information in the presentation.

In the time between taking the picture and presenting to the class, the instructor will need to have the film developed and insert the picture into any material that will be presented in the class (PowerPoints, posters, etc.).

Day 2: Activity Presentation

The presentation prepared is a PowerPoint that includes student responses.

* Slide 1: Title slide
* Slide 2: Contents slide used to briefly explain what is in the PowerPoint
* Slide 3: Reviewing the human eye: This slide is to get students thinking about their current knowledge of the eye. With this slide the instructor should focus on the function of each part of the eye in focusing light onto the retina.
* Slide 4: This is a different view of the human eye with the picture of a tree and how that picture moves through the eye. While on this slide the students should gain a more detailed understanding of what each component of the eye does and how the image is placed on the retina
* Slide 5: This is a detailed explanation of the structure of the Retina. The instructor should use the diagram to explain how light flows through the retina and how each component is connected.
* Slide 6: This is an explanation of the process of seeing a light wave and how it is converted to electricity then transmitted to the brain.
  + There are two examples, the first is a single wave coming in and hitting a rod. This is explained by the instructor as the wave comes in the energy from the wave is changed into an electrical charge that originates in the rod (represented by the arrow). This charge moves through the bipolar cells and then the ganglion cells and finally get transmitted to the brain on the optic nerve.
  + The next part of this slide asks for a student to explain how we see colors (the previous example does not show us color) if no one volunteers nudge then by showing a purple wave. This wave is turned into electricity in the red and blue cone. These cone transmit the electricity to the horizontal cell where the signals are combined into one signal that indicates purple. This signal then follows the same path to the brain.
* Slide 7: This slide shows the two types of cameras. The instructor should talk about how a digital camera sees pictures in pixels and when they are put together they form what is conceived by humans to be a continuous picture. Each individual pixel is sensed by the camera and stored in memory. The film camera uses light sensitive film that changes its properties when different colors of light hit it.
* Slide 8: this is an example of how light flows through a digital camera. The point of this slide is to show students that there are very similar components in an eye and a camera. Ask, can anyone name what some of these components are similar to in the eye. Some people can say the iris is like the aperture, the front lens (the outside one) is like the Cornea, The innermost lens is like the lens in the eye, the shutter is like your eyelid (except its inside the camera). Note: in this example, instruct the student that the mirror and the viewfinder is not important.
* Slide 9: This is a diagram of a pinhole camera and how light flows through it, this is valuable because it shows the very simple properties of light. The instructor should state how this can be used as a very simple model of the eye because the image in the back of the camera is the same as what the image would be in the back of the eye.
* Slide 10: Just as there was a detailed description of how the retina is structured. There is also a detailed description of how the digital sensor array is structured, however before we can do that the students must know what a photodiode is. The photodiode is a light sensor, when a light wave that has enough energy enters the photodiode it will knock one electron into movement causing electric current. This current can be measured thus telling us how much light has entered into the photodiode.
* Slide 11: This simply asks the question, what does the retina of the eye look like. At this point the students shouldn’t know what the digital sensor array looks like. The goal of this question is to give student a chance to realize that the sensor in a digital camera is an array of photo diodes. If no student offers this information, then ask what is similar in the eye to a photodiode (the answer is rods and cones) and then coax them into realizing that there is a network of rods and cones in the eye and it must be similar in the camera. If the answer comes really fast or the students seem to need more of a challenge ask them if they can tell you how a digital camera sees different colors (the hint to this can be that it takes a certain amount of energy to knock an electron into movement and different colors of light have differing wavelength).
* Slide 12: This is where students can actually see what a modern photosensor is like. The photosensor is built in layers blue has the longest wavelength and therefore the photodiode that will accept this will turn all blue light into electrical signal while the red and green flow through (same for the green layer, letting red through). There are grids of these photodiodes and each one senses the amount of light coming in and transmits that signal to a controller which saves those measurements in memory. If the students need a challenge, then the instructor can explain that each row is measured at once starting with the bottom row of sensors, when this measurement is complete the information from each row is cascaded down like a waterfall and the bottom row is measured again. This repeats until each row has been measured. The last part of this slide asks why is this significant and you want the students to start thinking about why the digital camera is modeled off of the eye.
* Slide 13: This asks the question “what other inventions mimic the human form?” obviously there are many different answers to this questions so allow students to use their imagination. If no students offer any information move to the next slide.
* Slide 14: these are some possible ‘obvious’ answers. All of these items seem to mimic the human form and serve a specific function. Now, if no students answer it is the time to start coaxing them to think.
* Slide 15: These are some other items that mimic the human form (however they are non-obvious) if the students have not been very active ask them to explain how they think each item mimics the human form and what part of the body do they compare well with.
* Slide 16: this slide is meant to excite the students about the possibilities in engineering. The left photo is Velcro, the inventor of Velcro was on a hunting trip when his dogs got burs stuck to them, he brought these to the lab, observed them and later invented Velcro to mimic the burs. The right photos are wind mills that use each other’s aerodynamics to their advantage. The engineer who invented these observed movements of schools of fish in the ocean as an inspiration for these windmills.
* Slide 17+: This is where the instructor should place their class photos (maybe make some sort of grand finale and if time permits you can add multiple photos (digital camera, film camera, pinhole camera) and compare them for quality.

Day 3: Finger Activity

Begin the day by again stating that it is important in engineering to use past designs and nature to influence your designs. Because of this, today there is an activity to show how powerful anatomy is in engineering. Students should imagine themselves as robotics engineers, working for a company that is developing a robot. This robot is being design to pick up many kinds of objects with some sort of gripper or hand. Other engineers are working on a gripper design, however your team is tasked with developing a finger that will eventually be integrated into a human-like hand. Your boss wants to see a design idea and mockup

Timetable based on 40 minute period:

5 minutes – get in groups, introduction by teacher and material distribution

10 minutes – students look at materials and create drawing on paper of their design

20 minutes – construction of finger

5 minutes – Share with class (must be quick)

It is important to convey to students that failure is a part of engineering. The odds of all students creating a working finger are slim. Engineers plan for failures and use them as learning moments!

**Formative Assessments:**

The pre-test will be used as formative assessment

There are three questions in the PowerPoint that will help the COFSP Fellow gauge how well the material is being absorbed.

**Summative Assessments:**

Along with the Pre and Post Tests, I have included a rubric to evaluate the Finger Activity.



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| **Differentiation:** |

At its core the lesson and activity were designed to be all inclusive based on the level of detail in which the instructor decides to make the student accountable for. At the Junior-Senior level (the level I taught this activity at) all students will be able to point to parts of the eye that correspond to the camera because it is a very visual process.

The first objective where students might have problems is the tracing of the light moving through a camera, and in my implementation this information was only used as an interesting piece of knowledge. I did this because I could see to fully grasp what was happening in these diagrams, there would need to be more background.

The second objective where students could have problems is the naming of inventions that mimic nature. This is why in my presentation there were three different slides of examples, each more complicated than the last. The point of this is to ask and get as many responses from the students as possible, then explain how the rest of the examples on the presentation connect to nature.

There is also the possibility that there will be some confusion when building the model fingers. This can be easily remedied by the addition of examples, step-by-step instructions, multiple levels of refinement after the first build, or the decrease of expectations in the activity.

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| **Reflection:** |

After the implementation of my activity, I am proud to call it a success. The activity went exactly to plan with some small exceptions like talkative students, or some students not participating in the activity. However, the schedule was perfect and almost all of those who chose to participate seemed to come away with some meaningful knowledge. However this is not to say that the plan was perfect.

When I was implementing the activity this time I was under some less than fortunate circumstances. If I was able to spare more time in the classroom then the activity could benefit greatly from this. To truly come away from the finger activity with as much as possible, it would be best to include multiple rounds of refinement. If students are able to fail once, then redesign their finger again I think the activity could hold more meaning because the majority of students should be able to make a meaningful product. If enough time is given, it might even be possible to have students design hands or grippers.

In regards to the presentation, I think that this was a great success. Something that made this so effective was the amount of knowledge students had on the anatomy of the eye coming in. If there was a way to also give students background knowledge on the photodiode, or electricity in general I think the activity would have been that much more impactful.