SEEING THE LIGHT: TEACHING CHILDREN ABOUT THE EYE AND LIGHT ADAPTATION

By

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Abstract

My thesis was with Dr. Eggers specifically I worked on the Arizona RETINA Project. The goals of the RETINA project is to study how light adaptation works in the eye and to inform the public about the eye, the latest research about the eye, and to encourage a love of science. My project was a research based outreach project. The goal of the project was to produce an experiment and lesson that most effectively communicates the research that is occurring right now by Dr. Egger's lab and other labs as well the basic process of how the eye works. One of the most important aspects of science is disseminating the information we are learning to not just other scientists, but to the general public which is why this project is so valuable. The outreach learning techniques that I used evidence based practices in order to best inform the students.

Seeing the Light: Teaching Children About the Eye and Light Adaptation

I) Initial Rationale

For this project I designed a lesson plan to teach local middle school students about the eye and what light adaptation is. I worked on this project for Erika Eggers, Ph.D. Dr. Eggers won a research funding called the NSF CAREER Award, from the National Science Foundation to study the role of inhibition in light adaptation of the OFF retinal pathway. One of the components of the award is to educate the public about the science being performed in the lab. In response Dr. Eggers created the Arizona Retina Project. The goal of the Arizona Retina Project is to educate the public about how the eye works, current eye research, and light adaptation. The Arizona Retina Project is run by Dr. Eggers and a group of students. It currently consists of a blog, Facebook page, Twitter page, Instagram, Snapchat, Pinterest and outreach events such as Future Innovators Night and Arizona Festival of Books. I came in to create an outreach for the local middle school children. This has consisted of building a lesson plan, presentation, worksheet for our light adaptation box and a test to see how much the students have learned (See Appendix A, B, C, and D respectively to examine these components. Finally I wrote blog posts every other week that has information on eye conditions, eye research and in one instance recipes that are high in nutrients the eyes need. See Appendix E for a hyperlinks to all blog posts done this year.

II) Evidence Based Teaching Practice

In order to begin this project I needed to ensure that all of the ideas I wanted to implement were based in evidence based teaching practices. Evidence based teaching practices are strategies and techniques teachers can use that have been scientifically proven to be effective

for children to learn the concepts. In my research I found there are currently two main ways of teaching in science today, teacher centered learning and context based learning. Teacher centered learning is the classical style of learning that students have been traditionally taught by. Teachers stand in front of the classroom and speak to the class about the topic. It has little to no collaborative learning and minimizes student interaction with one another and the teacher outside of a question and answer format. The assumption that is made is that students our willing recipients of the knowledge that the teachers are passing onto them (Pinnegar & Erickson, (2010). The students who come into to be taught this way are often taught with books along with the teacher's lessons. This type of learning has been found to have many students not capable of applying the concepts they learn outside of the classroom. Students taught with this are less likely to enjoy learning science and reduced their interest in science. Pinnegar and Erickson were able to find that classrooms were better controlled. Gilbert was able to show in college chemistry class students who learned utilizing context based learning scored significantly higher on average than those who were learning via teacher centered learning (Gilbert. 2006).

Context based learning is based upon three learning theories: constructivism, situated learning and activity based learning (Gilbert, 2006; Mandl & Kopp, 2005; Edwards, 2009; Berns & Erickson, 2001). Activity based learning theory takes into account the group as a whole including their cultures, histories, socioeconomic status, and other complex issues which allows students to look at qualitative research and examine patterns. Situated learning theory states learning cannot be properly attained or separated from the context that the concept occurs (Bell, Maeng, & Binns, 2013). The reasoning behind this theory is students will be utilizing their knowledge in the real world not in a structured setting. Constructivism theory states knowledge is built upon by a person's experiences and the meaning of those experiences (Pinnegar &

Erickson, 2010). Active learning is based on constructivism learning theory. This form of learning emphasizes the students working in conjunction with one another and the teacher in order to understand concepts. I was able to find across multiple papers Gilbert in 2006, Pinnegar & Erickson in 2010, Berns and Erickson in 2001, and Hattie in 2009 that constructivism and active learning have proven to improve students' understanding of the concepts. It increased their ability to apply the concept to problems outside of what they learned. Active learning also increased test scores, increased ability to self-study and increased rates of positive attitudes towards science and the other concepts they were learning compared to teacher centered learning. Some other benefits found was better teacher student relationships, increased questioning and synthesis, and increased ability to verbally communicate thought processes, ideas and concepts. The key aspect to this learning type is teachers need to be activators in the classroom not just facilitators (Hattie, 2009). This allows for a classroom to be controlled while still allowing the students to learn in a collaborative way and allows the teacher to bring up thought provoking additions or to steer the class into a more productive discussion.

III) Design of Lesson Plans

The first thing I did in this project was to make a list of the basic concepts that all the children should be able to understand by the time I leave the class. The list that I came up with was basic eye anatomy and function, what light adaptation is, and how light travels through the eye through the nerves and to the brain. Next I did research to find out the concepts the Arizona Department of Education requires middle school students to know. I discovered the Arizona Department of Education expects children in grade 6 to understand how the various systems of an organism interacts in order to perform a function (Arizona Department of Education, 2005a).

In this case how the vascular system nourishes the eyes and keeps them healthy how the nerves of the eye work together with the brain to from an image. In Grade 7 and 6 one of the primary goals is to have the students understand what scientists do, how to create hypotheses and experiments to solve a problem, and communicate the results effectively (Arizona Department of Education 2005a/b). In order to make my lesson plan (Appendix A) address these concepts, I ensured I added a portion that discussed how the different systems of the body work together so you can see. There is an experiment portion of the lesson. The experiment was a light adaptation box which the class will use to examine how long it takes different ages and genders to see the image on the back of the box after allowing their eyes to adjust to the darkness and then the light. This allows them to see how light adaptation works in real time and how quickly it occurs. Next there is a discussion so the children have a chance to communicate the results of the light adaptation box verbally and through a graph. The discussion will also include a part where we come up with ideas to make the experiment better. This part of the lesson addresses Grade 7 standards that ask children to understand how to communicate their results in different formats and effectively. Finally I made sure there was an optional component that would allow the class to create their own hypothesis and experiment to test an aspect of the eye they are interested in. This also addresses Grade 7 standards that ask children to be able to understand how to create their own experiments and hypotheses. The optional component will be discussed later in more detail.

The next step was to create a slideshow and lesson plan which laid out all the objectives I wanted to accomplish (Appendix B). The slideshow was primarily visual in nature. I reduced the amount of text that I had in the slide show because I wanted the students to listen to what I am saying and not what was on the board. It included information about me, light adaptation, eye

function and basic eye anatomy. The lesson plan addressed all of the components that I wanted to discuss, the light adaptation box experiment and included a potential exercise that had the students working together to create their own experiment.

After that I created a worksheet (Appendix C) that described the light adaptation box and how it works. This box had goggles attached that helped block out all light into the box. The participant put on the goggles and let their eyes adjust to the darkness. The experimenters then turned on a light and asked the participant to tell them when they could see the image in the box. They timed from the time the light went on until the participant told them they saw the image. After the experiment the two groups have tested at least 5 different people and they are asked to create a visual representation of the results. Each group would then come to the front of the class room and present to the class their results, their possible meanings, and what they could potentially examine in the future. The results could be graphed or placed in a table and comparing students of different ages or gender against the times. This complies with the grade 7 standards asking students to be able to communicate their results effectively.

Finally, I figured out how I was going to have students work to create their own experiment on the eye which complies with both grade 7 standards and active learning. I decided the students would be placed in groups of three or four. In that group the students would decide on a question they had for the eye and try to make an experiment that would be able to test their question using the materials available. Some examples of materials they would have are blindfolds, magnifying glass, paper, colored pencils, and glasses. The teacher and I would go around helping the students think of experiments that would test their questions. Next the students would have to create a hypothesis about what they think the results of the experiment would be. The class would put their experiments on the board and we would vote on which

experiment we wanted to try. The experiment with the most votes would be the experiment that as a class we would actually try to perform to see whether or not the hypothesis was correct.

I wanted to ensure that students had a chance to get up and do instead of listen to me talk at them. When I am discussing the anatomy and function of the eye, my goal was to have students come up and physically act out the parts of the eye and then demonstrate how light travels through the eye. Two students would be the pupil of the eye and two more the lens of the eye. A group of students would be in a circle representing the sclera of the eye with the goal of maintaining the shape of the eye. Two students would be either a rod or a cone they would be holding hands with students (approximately six) who represented the optic nerve. At the end of the optic nerve was a student who represented the brain which would be by the white board. I then would take an object in the classroom like a book and tell them that it will represent the light moving through the air. I would move the book through the pupil and lens. The moment it goes through the lens I would flip the book upside down and change my angle so it better hits the "cone and rod". After that I would move the upside book until it hits the cone and rod which "activate" and transmit a "signal" which is signified by the students beginning the wave which is transmitted along the optical nerve until it gets to the visual cortex of the brain. The person who is the visual cortex will then draw a picture of the book. A diagram of this is in Appendix H. This would be a way for the students to visually see and participate in how the eye and brain work together to allow us to see. I think that this demonstration would help the students better understand how the eye works because they get to see how it literally moves. This will be done in conjunction with showing the students the retina model made by my fellow classmates for the Arizona Retina Project. Hopefully by verbally describing, visually showing and having them physically demonstrate the concepts, I am able to convey the information to the students in

different ways and repetitively and so they will be better able to understand and incorporate those concepts.

The last component of the project that I did was to create a way for us to evaluate whether or not the students understood the objectives we wanted them to get out of our lessons. I did this by creating a pre and a post test that could be given to the students. The test comprises of matching terms and definitions, true or false questions, short answer questions, and drawing. The students would take the at-home test approximately a week before we came so we know how much the students know before we go into the classroom. This would allow us to see adjust the lesson and lesson plan according to the knowledge base of the students. A week after we come the students will be given another take home test that would assess how much they learned. The tests are nearly identical with some questions changed. The questions that changed were ones that allowed them to provide qualitative feedback for the Arizona Retina Project to refine the classroom outreach. On the pretest a question is asked about what the students are interested in learning so we can add that information into the presentation if possible. The tests allowed me to see how student's answers change based upon what they learned. One key aspect is to impress upon the students the test will not be a part of their grade and if they do not know the answer to make a guess or leave it blank. The post-test allows us to see what concepts they didn't understand which allows the lesson plan can be adjusted accordingly in the future. I tested each of the tests on my younger cousins ranging from age 9 to 14. Ten of my cousins took the test. I went through each question with them individually and had them provide feedback and ensured the questions were clear to them. This meant that I made approximately 6 different versions of the tests until I got to my final version found in Appendix D.

IV) Testing Concepts at SARSEF Future Innovators Night

In order to evaluate the on hands concepts I planned to teach the children I gave them a three question test at the SARSEF Future Innovators Night to see if they understood the concepts we were teaching them at the event (Appendix F)**.** The four main concepts that were being conveyed were what light adaptation is, how light travels through the layers of the eye, how signals are sent from the nerves to the brain, and that light flips upside down when it goes through the eye. We conveyed these topics in a variety of ways. Our group had a specific order the children were taught so the concepts built on top of one another and built upon the knowledge taught at the station before.

The first station had a model demonstrating how light flips when going through the eye. It was comprised of a fish bowl filled with water, a light with a cut out of a smiley face attached, a cut out iris on the front of the fish bowl and tissue taped to the back. The tissue on the back mimics the retina and gives the light a surface to bounce off of. When the light was turned on and shined through the iris the smiley face that is seen through the fish bowl on the tissue paper is the smiley face upside down. This shows how light is bent and changed when it goes through the eye. For a picture see Appendix G**.**

The second station was an eye model that can be taken apart. It showed the three layers of the eye and as the person took apart the eye they would discuss the primary function of the layer. We referenced back to the fish bowl when describing how the lens bends and focuses the light to hit the fovea. We gave a more in depth description of what the retina does because it is the primary aspect of the research done by Dr. Eggers. See Appendix G for a photo .The next station was closely intertwined with the eye model. It was retina model that visually demonstrated all the nerves involved in sending signals to the brain to inform it of the light being seen. When a

light is shined on the eye on the front of the box, a photo diode in the model senses the light and sends a command to cause a series of lights to light up in a particular sequence along model nerves. After all the nerves have individually lit up the signal is sent along a thick “optic nerve” and to a brain where the brain itself lights up. This model allowed us to demonstrate to the public exactly how signals are being conveyed to the brain after light hits the eye. During this station the member of our group describes the process and also provides a more detailed description of the two main nerves involved in this process, cones and rods. For a photo of this and a link to a video of this station please see Appendix G.

The final station was the light adaptation box. This box allows us to model to the students what we mean when we are discussing light adaptation. The box is enclosed and the students place their face against the googles attached to the box and keep their eyes closed. While their eyes are closed I’d discuss with them what light adaptation was and give them an example of light adaptation they would recognize from their own life. The example was the moment when you walk out of the movie theater and you cannot see for a couple moments until your eyes adjust. The process of adjusting from dark conditions to light conditions is light adaptation. I would then discuss with them how Dr. Eggers is studying how that works because scientists have not been able to fully explain the mechanism by which that adaptation occurs. At that point their eyes will have at least begun the process of dark adaptation enough that when I turn on the light and tell them to open their eyes, their eyes have to take a couple seconds to adjust in order to see the faintly drawn eye on the back of the box. See Appendix G for a photograph of this box. After they went through all of these stations they would take a test which evaluated what they had learned during this time.

The conclusions I came to was the children were not able to understand what light adaptation with the way we were presenting it in the class. In 14 out of the 24 (58%) responses they were not able to answer the question or the answer was completely inaccurate. The other 42% of responses were correct in varying degrees, however I always gave the students the correct answer after they said they didn't know and approximately 50% of those were able to write down a good answer after my explanation. In the end only 5 students understood what we were trying to convey in our explanation of light adaptation. The adults we spoke to were able to adequately understand what we were attempting to demonstrate and occasionally tried to lead their children to the correct answer by reminding them of the explanation we gave them. This concept is difficult to understand and it seems we have managed to get it to become understandable for those over the age of 14, but the children below age 14 were having a harder time.

A solution I came up with is multifaceted. I discovered that when I had the students break down the words light and adaptation and tell me the definition of both, they were able then to make rather accurate guesses as to what the two words put together might mean. Adding in an example of going from a movie theater to the outside additionally seemed to help. I hypothesize though if we help define the definition of light adaptation they come up with and ask them if they have any examples of this phenomena, this is a form of active learning. By coming up with their own examples, students are better able to relate the concept they just learned to an experience their understanding will be more concrete, this is based in situated learning. Another solution to this problem is to make the children experience light adaptation in a more dramatic way than just having the light box. I will purposely have the lights in the class room turned off during the course of my presentation and will have the students close their eyes while I describe why we are

studying light adaptation. Then I will turn on the lights at the same time I have them open their eyes, this gives them more of a context to base their understanding of light adaptation. This should provide a good demonstration to the children exactly what I am talking about when I say light adaptation. After these results I have integrated these solutions into my lesson plan.

The next question asked how light traveled through the eyes. The majority (80%) of the students were able to show the basic way light travelled through the eyes beyond just the light hitting the eye. My cousins showed the most common answer with this question before we educated them was a drawing of the front of the eye, a sun, and "light rays" hitting the front of the eye. The 80% who answered correctly at least added an optic nerve to the drawing which showed they understood that the light does more than just hit the front of their eye. Many were able to draw the entire eye with the layers, the optic nerve and the brain. The eye model and our retina model along with the explanations that went with them were doing a good job of explaining how the eye interacts with light and how it travels through the eye. I do not believe how we are currently teaching these concepts need to be changed. The children under the age of 10 had a harder time understanding how the light travels through the eye which may be because the concepts can be difficult.

The final question on the test was "what will a smiley face look like when it hits the back of your eye?" 63.5% of the students were able to answer this correctly. The problem I with this question specifically was that some of the students who did not answer this question had not gone to the station that showed how when light travels through the eye. I believe that the results for this was skewed and the students who actually saw our fish bowl demonstration often understood the image is flipped when it hits the back of the eye and the brain flips the image to be the correct way.

V) Conclusions

This project will be posted in our kids section on our blog so teachers can utilize the lesson plan in the future. Hopefully the project will be able to work with the University of Arizona's Science Outreach group to get students into classrooms next year and utilize this information that I created for them. I did reach out and try to get into classrooms, but I believe because I didn't get an early enough start I was not able to get into classrooms. Many teachers have their lesson plans set far ahead of schedule and so the sooner we can reach them the more likely we would be able to do the optional activities that are more hands on. Also if the relationships can be built there is a good chance that we will be invited back year after year. Additionally this project can easily be adapted for high school students. I believe that Anatomy and Physiology classes might be very open to us coming in and talking to the students during the senses portion of the class. It is an opportunity I think we should seize and utilize because they are learning these concepts and they would also understand the research that is being done in Dr. Egger's lab. Overall I have had a wonderful time doing this project and am glad I got to be a part of an interesting, high achieving group of students that care about educating the public.

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Appendix A- Lesson Plan

Objectives:

- Describe what a scientist is and what a scientist does
- Ability to describe the basic components of the eye
- Ability to describe the basic function of the eye
- Ability to describe what light adaptation is

Introduction:

- Introduce yourself to the class
- Ask the class to tell you everything they know about the eye
- Ask them what they know about scientists
    - Tell them about what a scientist does: a scientist is someone who studies the world around them. They do this by making an educated guess about how something works, this is called a hypothesis. Scientists then perform experiments in order prove or disprove the guess they made. If they can prove their guess and they can prove it more than once then it shows that there is a good chance their guess may be true. If more than one scientist can show your guess was correct by performing their own experiments then it becomes a fact.
    - Have them think up some words that describe a scientist, then tell them your words. Creativity, teamwork, communication, writing,
    - Show them pictures of labs to demonstrate all the different types of science that there are available to them.

Eye Basics

- The eye is used to see. We will get into how that happens later.
- The eye is considered the only part of the brain that is visible.
- The nerves that are in the eye communicate to a part of your brain called the visual cortex that is on the back part of our head. The visual cortex is what takes the messages the eye is sending to it and builds a picture which is what we see.
- Three layers to the eye:
    - Sclera and cornea:
        - Tough white part of your eye and clear part over your iris.

        - It protects the layers inside of it from the outside world.
        - Additionally it gives your eyes their shape. Without it our eyes would squishy and unable to stay in it's shape
    - Choroid
        - This is the layer of the eye that is a network with blood vessels.
        - This layer provides food and oxygen to the eye so it can stay healthy.
    - Retina
        - This is the layer of the eye that we use to see.
        - The layer is made up of nerves. Does anyone know what nerves do?
            - Nerves are a type of cell, just like muscle cells, skin cells, etc.
            - Nerves specialize in sensing the outside world and translating what they are sensing into a message the brain can understand. Nerves also take messages from the brain and tell different parts of the body what to do. Every time you move that is your brain sending the message to make your muscles move through the nerves.
        - There different types of nerves in the eye but the two most important are cones and rods.
            - Cones are nerve cells that allow us to see color, fine details, and see clearly in bright conditions. Cones don't work well at night but do great job of seeing in the sunlight or lit up room
            - Rods are nerve cells that allow us to see in black and white, allows us to see shape and movement, and let us see in dim light. They are important in night vision, but don't work as well in the sunlight.

- How do you see?
    - Light travels through the eye by going through the first the cornea and your lens. It then gets focused on the back of the eye to your cones and rods are. The cones and rods fire electrical pulses, or messages, when the light hits them. The messages travel along a pathway of nerves called the optical nerve. The optical nerve travels through the brain until it gets to the visual cortex that takes the message and builds an image that you see.
    - One really cool thing that happens is that when the image enters the eye it turns the image upside down. If you look at this model when you shine the light through the magnifying glass the image gets flipped upside down in the fish bowl. Your brain then rebuilds the image to be right side up.

    - Do the activity described and diagramed at the end of this.

- Light adaptation
    - Light adaptation is when your eye adjusts from dark to light conditions
    - Do you remember when you go outside from the classroom or movie theatre and you can't see for a couple of moments because it is too bright. Then after you blink a couple times all of the sudden you can see? That is light adaptation!
    - We don't really know how your eyes do that. You guys are going to help us find out more about how it works. I have these boxes inside is a drawing on the back. We are going to have you keep your eyes closed so you get used to the dark when your face is against the box. You need to keep eyes closed for a minute. Your partners will time you when you do that. Then at the same time as you open your eyes some will start a timer and another will turn on a flash light. As soon as you can see the image stop the timer and tell the person. Next you will right down your age and gender and the time. Everyone in the class will do this. You will be making a graph to see if age or gender matters to how long it takes your eyes to adjust to the light change.

Optional if there are two class periods or long class periods: At the end have them talk about what they want to learn about the eye and get them into groups of 3-5 students. Each of those groups need to come up with an experiment to learn more about the questions they have about the eye. They will get a piece of paper where they will make up the experiment and present their experiments. The class will vote on what they want to do and we will actually perform the experiment that one of their classmates designed.

Physical Activity to demonstrate how light moves though the eye and nerves: Putting it all together

Two students would be the pupil of the eye and two more the lens of the eye. A group of students would be in a circle representing the sclera of the eye with the goal of maintaining the shape of the eye. Two students would be either a rod or a cone they would be holding hands with students (approximately six) who represented the optic nerve. At the end of the optic nerve was a student who represented the brain which would be by the white board. I then would take an object in the classroom like a book and tell them that it will represent the light moving through the air. I would move the book through the pupil and lens. The moment it goes through the lens I would flip the book upside down and change my angle so it better hits the "cone and rod". After that I would move the upside book until it hits the cone and rod which "activate" and transmit a "signal" which is signified by the students beginning the wave which is transmitted along the optical nerve until it gets to the visual cortex of the brain. The person who is the visual cortex will then draw a picture of the book.

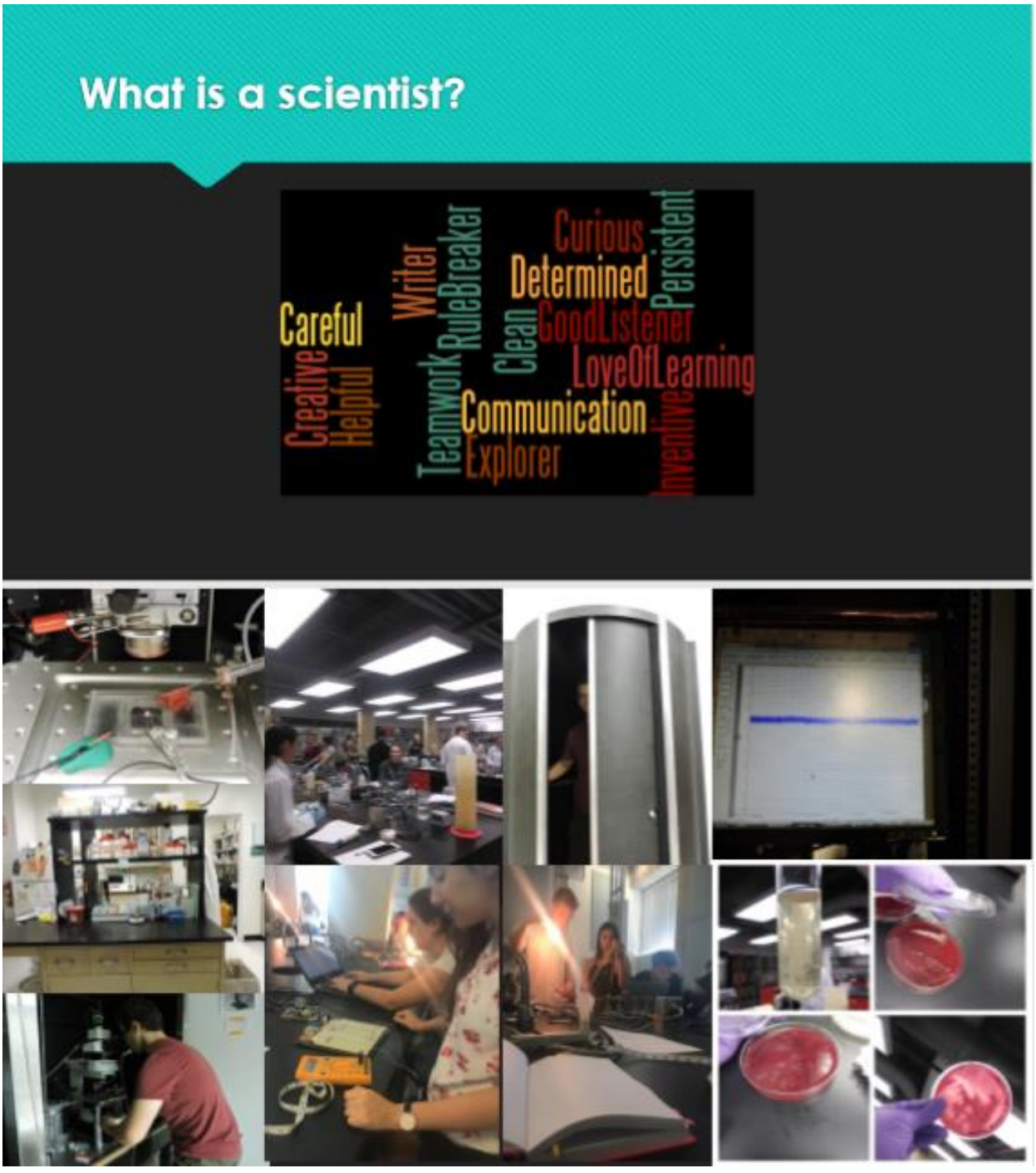
Appendix B- Presentation

The Eye

By: Marissa Paz

Who Am I

- Student at the University of Arizona
  - Senior
  - Microbiology
  - Physiology
  - Public health
- Goals:
  - Family Practice Doctor
- Here with Arizona Retina Project

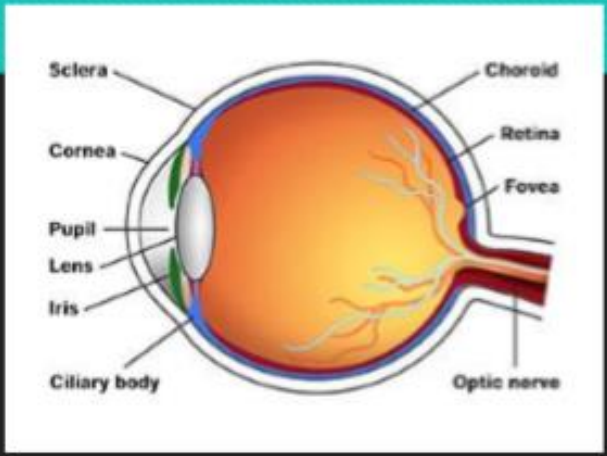

What is a scientist?
Careful
Creative
Helpful
Writer
RuleBreaker
Teamwork
Clean
Curious
Determined
GoodListener
Persistent
LoveOfLearning
Communication
Explorer
Inventive

The Eye

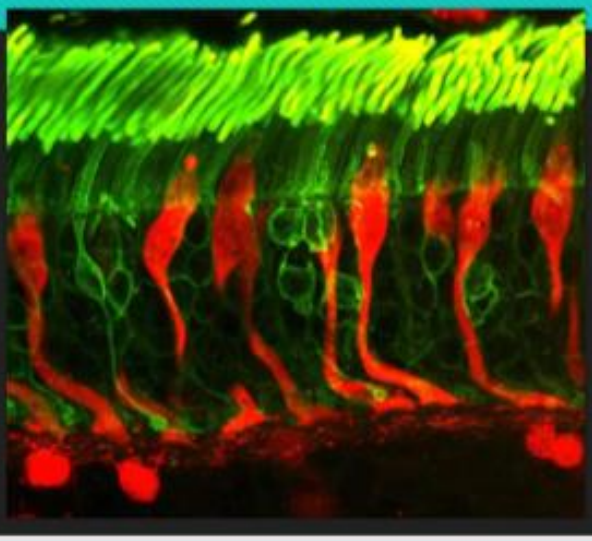
- Basic Facts
  - Used to "see" with
  - Part of the brain
  - Talks to Visual Cortex

Eye Layers

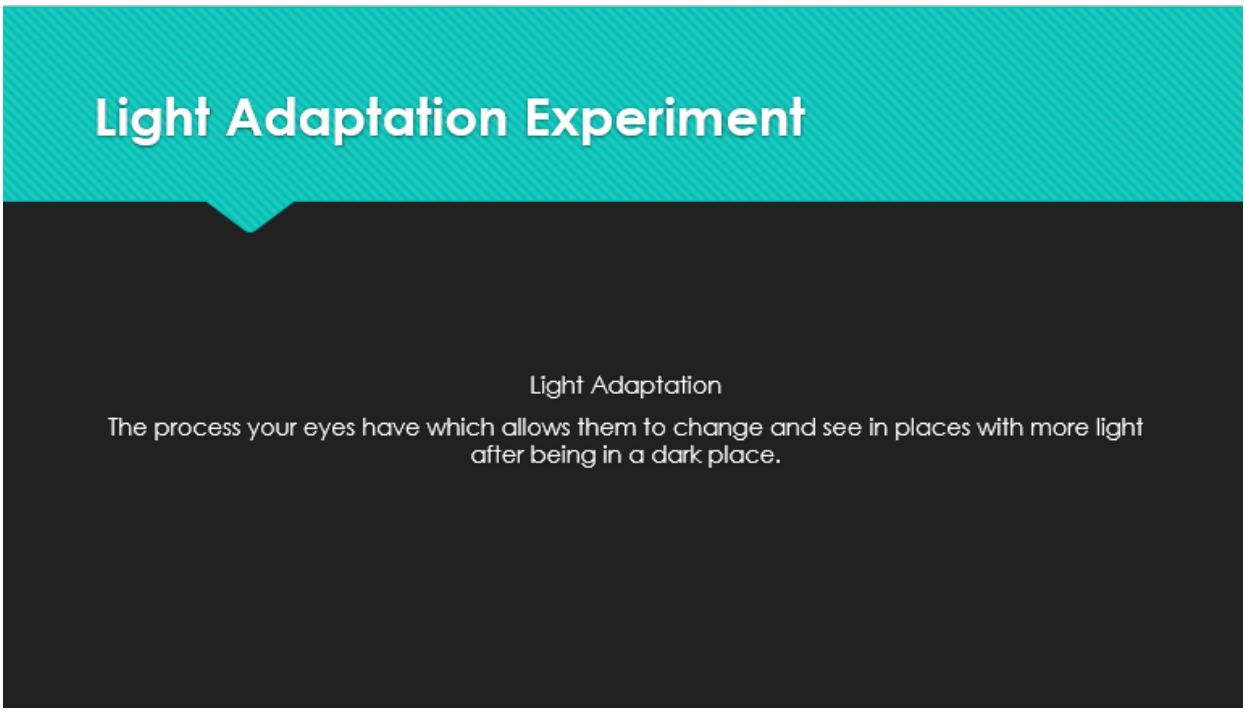
- Outer Layer-Sclera and Cornea
  - Protection
  - Form
- Middle Layer-Choroid
  - Provides food and oxygen
- Inner Layer-Retina
  - Lets us see
    - Cones-Colors and details
    - Rods-See in dark areas



Rods and Cones



How You See


Light Adaptation Experiment
Light Adaptation
The process your eyes have which allows them to change and see in places with more light after being in a dark place.

Appendix C- Worksheet

Light Adaptation Box

What is light adaptation?

Light adaptation is the process of your eyes adjusting to more light in the environment.

There are multiple ways that your eyes do that. One way is by making your pupils bigger or smaller to change the amount of light that is being let into the eye. When there is a lot of light then pupils get smaller so not as much light gets in and when there is not as much light then pupils get larger. Turn to the person next to you. Have one person close their eyes and keep them closed for 30 seconds. Person with their eyes open look at your partner's face and have your partner open their eyes. Look at how their pupils grow and shrink as your body tries to figure out how much light to let in. We are still studying other ways how our eyes adapt to light including how our nerves are involved in that process.

Instructions

1. Split yourselves into two groups and grab a light adaptation box and a timer.
2. Each group will have someone who knows what the image is, a timer, a recorder, and test subjects.
3. The test subject will close their eyes and place their face against the mask on the box. They will wait for their eyes to adjust to the darkness for at least 20 seconds. The student behind them will be blindfolded so the experiment can go faster.
4. At 20 seconds the person who knows the image will turn on the flash light in the box, the test subject will open their eyes and the timer will start the timer. When the subject sees the image they will ask for the timer to stop and whisper it to the person who knows the image.
5. If they have it correct, the time must be recorded. If not then the student must go back, have the timer restarted and look again. If the student takes more than 2 minutes then the timer is stopped and that time is recorded.
6. The recorder must ensure that every test subject's age, gender and time are recorded.
7. After you have done this for at least 5 different test subjects display your data on a graph and table.
8. Come up with as a group a conclusion about the results and ways to make the experiment better.
9. Present your results, conclusions and ideas to improve the experiment to the class.

Appendix D- Pre and Post Test

Pretest

Matching: Match the words to the correct statement.

A. Cone
B. Brain
C. Rod
D. Sclera
E. Eye
F. Retina
G. Lens

_____Structure that “sees” images

_____Cell excited by colors

_____Excites cells in eyes

_____Focuses light Retina

_____ The layer of the cells that light into an electrical signal

Draw how light travels through the eye.

True or False: Write true if the statement is correct and false if it is not correct.

_____ The eye is a part of the brain.

_____ Scientists know everything about the human body.

_____ To be a researcher you have to be good at following directions

_____Science is awesome

Short Answer:

What does a scientist do?

What are some characteristics of a scientist?

Do experiments always work?

What do you want to learn about the eye?

What is light adaptation?

Posttest

Matching: Match the words to the correct statement.

_____Structure that “sees” images
_____Cell excited by shapes
_____Excites cells in eyes
_____Focuses light onto retina
_____The layer of cells that translate light into an electrical signal

A. Light
B. Cone
C. Brain
D. Rod
E. Sclera
F. Eye
G. Retina
H. Lens

Draw how light travels through the eye.

True or False: Write true if the statement is correct and false if it is not correct.

_____ The eye is a part of the brain.

_____ Scientists know everything about the human body.

_____ To be a researcher you have to be good at following directions

_____Science is awesome

Short Answer:

What does a scientist do?

What are some characteristics of a scientist?

Do experiments always work?

What is light adaptation?

Did you enjoy the lesson and experiment? What was your favorite part of the experiment?

What did you not like? How can I make it better?

Appendix E- Blog Posts

- Blog 1 was on a genetic therapy used by researchers on monkeys in order to give them the ability to see certain colors that need the L-opsin gene aka red cone. Here is website for that http://azretina.sites.arizona.edu/node/173.
- About me Post gives a short description about what I am doing with the Retina Project as well as some background information on me. Click on this link to read that post: http://azretina.sites.arizona.edu/node/192.
- Blog 2 was about the different types of colorblindness, how colorblindness. Click on this link to read that post: http://azretina.sites.arizona.edu/node/193
- Blog 3 was on Charles Bonnet syndrome, a common visual hallucination syndrome that occurs in people who are losing their eye sight. To read this post go to http://azretina.sites.arizona.edu/node/212.
- Blog 4 and 5 were both related to the same topic. I created adult and children friendly recipes that are filled with foods that are important to the health of the eye. The adult's recipe post can be accessed by going to http://azretina.sites.arizona.edu/node/226. The children's recipe post can be accessed by going to http://azretina.sites.arizona.edu/node/225.
- Blog 6 was on a gene therapy that was under review by the FDA as a cure for a type of genetic blindness. To read this post go to http://azretina.sites.arizona.edu/node/248.
- Blog 7 was on a new way of treating glaucoma using electromagnetics that is under clinical trials. Access it at http://azretina.sites.arizona.edu/node/259
- Blog 8 was on eye shaving which is a Chinese technique that is being used to treat dry eye today. Read it here: http://azretina.sites.arizona.edu/node/268.
- Blog 9 was on the lasting effects of Ebola on the eye and can be read at http://azretina.sites.arizona.edu/node/285.

- Blog 10 was on vision therapy and convergence insufficiency. To be read at http://azretina.sites.arizona.edu/node/291.
- Blog 11 was on the first commensal bacteria found in association with the eye. Read it at http://azretina.sites.arizona.edu/node/302.

Appendix F-SARSEF Future Innovators Night Test

Age: Gender:

1. What is light adaptation?

2. How does light travel through the eye? (draw a picture or describe)

3. What will the smiley face look like when it hits the back of your eye? (Draw a picture)

Appendix G- Pictures of the Stations

Station 1: Fishbowl model

Station 2: Eye model

Station 3: Retina Model (This was created by two other

Link to Retina Model Video: https://arizona.box.com/s/1mggffk4a8zhusx8czrpn6oczl2392es

Link to how it was made: http://azretina.sites.arizona.edu/node/307

Station 4: Light Adaptation Box

Appendix H- Diagram of Light Travelling through the Eye and Signaling to the brain4