Roy G. Biv:
The Life and Times of a Scientist and an Artist

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This curriculum unit is recommended for:
Chemistry, Art, Physics, and Physical Science
Students in Grades 9-12

Keywords: ROYGBIV, electromagnetic spectrum, light, wavelength, color, reflection, absorption, pigment

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: The seminar I took focused on the Art and Chemistry of light. This will also be the focus of this CU. I will have the students personify the visible light spectrum ROYGBIV (red, orange, yellow, green, blue, indigo, and violet) by turning the EM Spectrum between 450 nm and 750 nm into a person Roy G. Biv. Students will study and do experiments pertaining to the physical, chemical, and life providing properties of light. Students will also explore the role of light and color in the art field. As a final project and comprehensive assessment, the students will present Roy G. Biv as an artist and a scientist and create a portfolio of artwork and scientific experiments as a final project.

I plan to teach this unit during the coming year to 30 students in grades 11-12.

Introduction

Imagine our world without color. I do not mean like how when we watch an episode of "The Twilight Zone" or a movie like "Casablanca"; where we lose ourselves in the show and dub it a 'classic'. We forget that the world was not actually Black and White back then; that technology had not caught up with the human imagination or reality yet. The Millennials and GenZ laugh at the technology of older horror movies like Godzilla and lose themselves in the world of virtual reality, 3-D movies and IMAX.

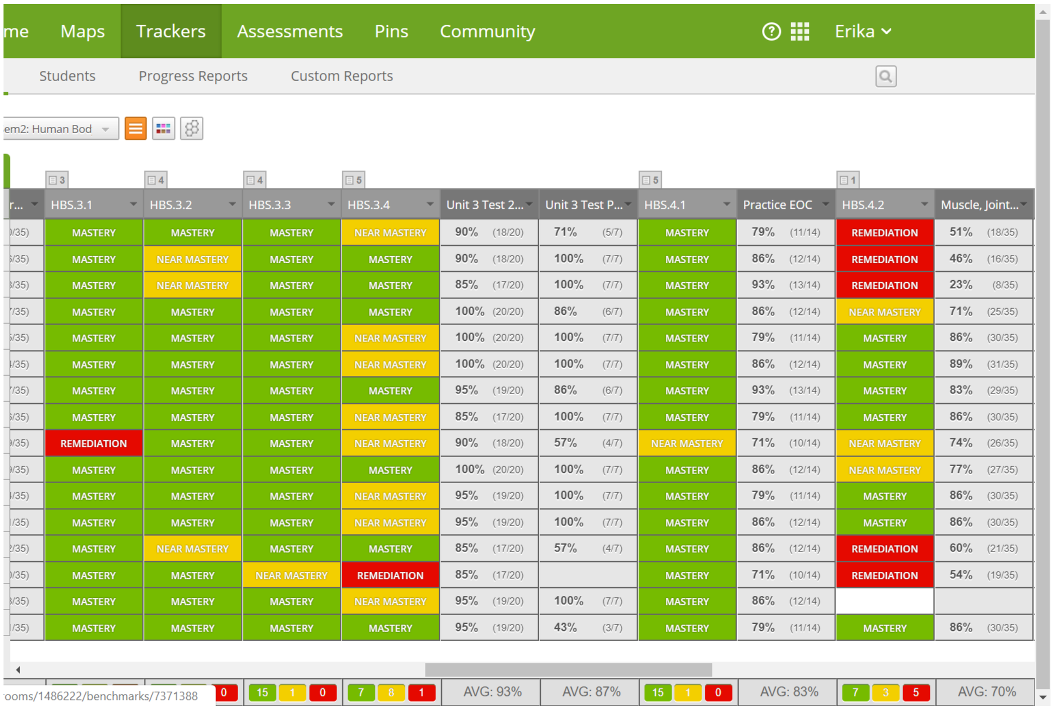
What I would like my audience, and eventually my students, to do is imagine they were spirited from this world of color into a land of black and white. No Carolina Blue, or Crimson Red, or Green and Gold school colors, gleaming on the quarterback's jersey or off the tassel of the tall hat of the drum major. If their pizza were not covered in bright red pepperoni and deep red sauce would it taste the same? Would their mood and personality remain unchanged? Would students' creativity and imagination be affected in school if there were only black and white?

The fact of the matter is that COLOR MATTERS. Remember the preschool classic *Green Eggs and Ham* by Dr. Seuss? The main character was sure that he did not like green eggs and ham because they were green ("I do not like Green Eggs and Ham, I do not like them, Sam-I-Am!"[1]) but he had never actually tasted them. The color made them unappealing, but once he actually tasted them, he discovered that they were delicious.

Color has the ability to change our mood and the perception of our world. Moreover, color is very important in education, so much so that entire systems would have to change if color-coding were no longer acceptable. Much research has been dedicated to how colors can help children learn more and enhance their memory.[2] Some education agencies suggest that certain colors, like blues and purples, have a 'calming' effect on children, while yellow and orange increase alertness. Could this be why preschool and kindergarten classrooms are always so bright and colorful? Imagine taking your kindergartener to meet their new teacher in "big school" and the walls are all dull beige with no colorful posters of shapes, colors, the days of the week, and the seasons. There is no colorful carpet for story time. Would you not wonder why the teacher did not decorate and make her room more welcoming? Would your child want to stay in the classroom?

When I was in elementary school, our buses numbers were color-coded. Not the buses themselves, but instead of having a student memorize a number, they memorized a color. The first window on either side of the bus had that color hanging in them. I rode the orange bus. I am not sure when primary teachers began using the color 'stoplight' system to modify behavior, but it is a practice that I remember well from my 17 year-old son's elementary years. I remember how he would come home from school, so proud that he 'stayed on green' that day; or hearing that my nephew's or cousin's favorite toy was taken because "they were on red all week".

I use the color code system in a data tracking system that our school uses to monitor student mastery of certain concepts. The concept is simple: green demonstrates mastery, yellow demonstrates near mastery, and red demonstrates the need for remediation. See the image below.



r...	HBS.3.1	HBS.3.2	HBS.3.3	HBS.3.4	Unit 3 Test 2...	Unit 3 Test P...	HBS.4.1	Practice EOC	HBS.4.2	Muscle, Joint...
/35)	MASTERY	MASTERY	MASTERY	NEAR MASTERY	90% (18/20)	71% (5/7)	MASTERY	79% (11/14)	REMEDIATION	51% (18/35)
/35)	MASTERY	NEAR MASTERY	MASTERY	MASTERY	90% (18/20)	100% (7/7)	MASTERY	86% (12/14)	REMEDIATION	46% (16/35)
/35)	MASTERY	NEAR MASTERY	MASTERY	MASTERY	85% (17/20)	100% (7/7)	MASTERY	93% (13/14)	REMEDIATION	23% (8/35)
/35)	MASTERY	MASTERY	MASTERY	MASTERY	100% (20/20)	86% (6/7)	MASTERY	86% (12/14)	NEAR MASTERY	71% (25/35)
/35)	MASTERY	MASTERY	MASTERY	NEAR MASTERY	100% (20/20)	100% (7/7)	MASTERY	79% (11/14)	MASTERY	86% (30/35)
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/35)	MASTERY	MASTERY	MASTERY	NEAR MASTERY	95% (19/20)	100% (7/7)	MASTERY	79% (11/14)	MASTERY	86% (30/35)
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Figure 1. MasteryConnect, a system of data tracking and assessments, uses a color-coded system to demonstrate mastery. Green is mastery; yellow is near mastery and red is not mastered (remediation). Students' names removed to reserve FERPA confidentiality laws.

Rationale

The reason I want to teach this to students is that I want them to realize the importance of color. I want them to understand that color comes from light. I want them to understand the scientific aspects of wavelength and absorption, as well as the artistic side that appeals to our emotions and thoughts. As a scientist, art is a tricky topic for me; so I will learn and art along with them. The school at which I teach focuses heavily on academics, with only a small art department. In my opinion, the arts (both visual and performing) and humanities are as important as STEM courses. Students need exposure to a broad variety of topics, even if they do not pursue the subject beyond the class. Color is unique in that it appeals to the scientific mind (light and its properties and processes) and the artistic mind (what is art without color?). I am choosing to personify light, instead of generalizing the topic of 'light' or 'color', I am transforming the topic into a person: Mr. Roy G. Biv. Mr. Biv is a contemporary Renaissance man, dabbling in both science and art. With his rainbow (or EM spectrum), he can make many wonderful things happen. I am choosing this method in order to keep the students engaged, which is just as important as students learning the material are. Students are much more likely to remember the material if they enjoyed learning it.

School Demographics

The school at which I teach, Phillip O. Berry Academy of Technology is located on West Charlotte. POB is a magnet school, which means we draw from a student pool all over Mecklenburg County. Out of a total of 1710 students, approximately 65% are Black or African American, 22% are Hispanic or Latino, 6% are Asian, 4% are White, and 3% are multiracial or of other ethnicities. Our school is totally immersed into STEM (Science Technology Engineering

Mathematics). In addition to the core classes (social studies, English, science, PE, and math), we have three 'academies' where students focus their studies, Engineering, Health Science, and IT. I teach in the Health Science academy. We also have a small arts department that offers band, orchestra, and visual art. I think the best characteristic of our school is the open mindedness of our students. I love seeing the blue hair, graphic novels, and the other ways in which our students express themselves. This unit will fit in perfectly with their willingness to learn new topics.

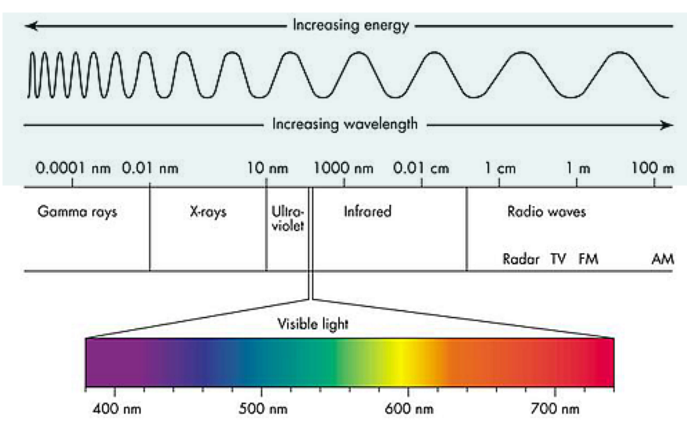
Unit Goals

My goals for this unit is to have students understand the concepts of color and light on a scientific level. I want them to understand the electromagnetic spectrum, specifically the visible light portion. Students will understand the science behind why we can only see radiation in that narrow 400 nm to 700 nm range. I want them to understand the principles of reflection and absorption, which is how color is visualized. I want them to understand that it is light (from the sun) that supports all life on earth, drives the hydrologic cycle, and controls the weather.

Content Research

If one is going to study light, one must first define light. When I googled *light* the first definition that popped up was *the natural agent that stimulates sight and makes things visible.* That is a good start, but not quite complete for me, a scientist. A better definition for me is *the visible part of the electromagnetic spectrum, between 400 nm and 700 nm* (see below for EM spectrum). This definition incorporates the visible portion of light, which is usually mentioned, and the fact that lights are on the EM spectrum, and therefore travel in waves. An individual particle of light is called a photon, described by Albert Einstein in the early 20th century to explain the 'particles' of light, rather than waves. The photon is represented by gamma (γ) and travels at the speed of light c (3×10^8 m/s).[3]

Figure 2



The electromagnet spectrum. Visible light is between 400 and 700 nm. Image courtesy of http://www.cyberphysics.co.uk/topics/light/emspect.htm.

Both in the scientific and artistic world, light is used interchangeably with color, because light separates into color. The colors of the electromagnetic spectrum are red, orange, yellow, blue, green, indigo, and violet (ROYGBIV). When I learned the colors in the 6th grade, we learned the acronym Roy G. Biv to remember the colors in order. What does light have to do with color? When ‘white’ light separates through a prism or other medium, one can see all seven ‘colors of the rainbow’. In a letter to a scientific journal , Isaac Newton wrote “And in order to have darkened my chamber, I placed a small hole in my window shuts, to let in a convenient quantity of Sunlight, I placed my prism at the entrance so it was thereby refracted to the opposite wall,…to view the vivid and intense colors produced thereby;….”[4]

Color is a reflection on light. Depending on what color we see, that color is reflected, or ‘bounced back’ off the medium and the other colors are absorbed into the medium. White light or color means all colors are reflected and black means all colors are absorbed. This can be proved with a simple paper chromatography test, in which a black dot is place near the bottom of a sheet of chromatography paper or filter paper and the paper is placed in a container of alcohol or even water. The colors will separate into the Roy G. Biv spectrum.

As stated in my introduction, light and color indicate symbols. Think about the colors at a traffic light. Red means stop, yellow means proceed with caution, and green means go; stop signs are red, school signs are yellow. An environment mean for focus and alertness would be bright and colorful, with plenty of light. A room meant for relaxation would be dim or dark, or have deep blues and purples. Our circadian rhythms or body clock, respond to light and dark as well. Melatonin, produced by the pineal gland, is produced in the dark hours. Called the hormone of darkness, melatonin promotes sleep.[5] People who work third shift often have a hard time adjusting to sleeping during the day and being awake at night. Often, they try to ‘trick the brain’ by making it as dark as possible in the room if they have to sleep in the daytime. Light can also control our mood. Light can be beneficial to the human mood, sunlight in a room can increase alertness and promote the release of serotonin. However, too much light at the wrong time, such as late at night (when we should be sleeping) affects health, increasing risks for high blood pressure, certain cancers and mood disorders.[6]

Light controls life. When I taught biology, I emphasized to my students that the ultimate source of energy for all living organisms is the sun. Through photosynthesis, plants absorb the sun’s rays with chlorophyll, a green pigment, and convert light energy into chemical energy (glucose). Whether the organism uses it directly through photosynthesis (green plants), or indirectly (eating green plants or eating organisms that eat green plants), the sun is the ultimate source of energy that drives live in the global ecosystem.

Light is essential for a healthy body. The human skeleton is our body’s foundation for support, protection and strength. The bones support our body weight, help us move, and make blood cells; thus, a healthy skeleton is essential. Humans use sunlight to produce vitamin D, a fat-soluble vitamin that is essential for healthy bone maintenance. Since foods do not enough vitamin D, the only way to get sufficient amounts is through exposure to the sun or taking supplements. Humans and most other vertebrate animals contain a sterol known as 7-dehydrocholesterol (7-DHC) in the skin that absorbs UV B rays and converts 7-DHC into pre-vitamin D. The pre-vitamin D is converted into vitamin D, an isomer of pre-vitamin D.[7] Vitamin D deficiencies cause a serious upsurge in cases of rickets in children in Northern Europe at the turn of the twentieth century. Doctors and nurses used to treat children; which involved stripping them down to their underwear, placing protective goggles on and exposing them to bright UV lights for one hour twice a week. After the rickets crisis reached the United States the WHO, (world health organization) recommended supplementing milk with Vitamin D.

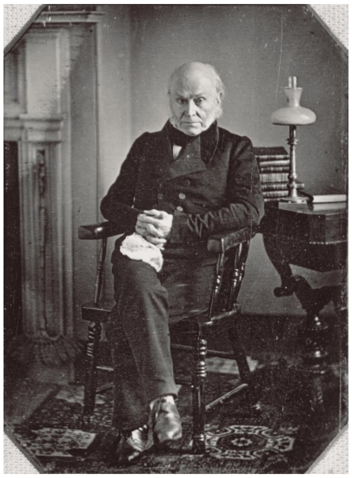
Figure 3 Equation for photosynthesis. Photo credit https://www.thinglink.com/scene/588821710954823681

$$6\ CO_2 + 6\ H_2O \xrightarrow{SUN} C_6H_{12}O_6 + 6\ O_2$$

Humans also associate color with emotion. Red symbolizes anger, blue-depression, green-jealousy; yellow can symbolize happiness or fear. Most smiley faces are yellow. Moods are sometimes described as 'dark'; meaning that a person is angry, depressed and short tempered. A 'bright mood' indicates happiness and benevolence. Black can symbolize death, and white can symbolize life; which is why people wear black to a funeral and babies are christened in a white gown.

I have saved one of the most significant applications of light and chemistry for last- photography. What would life be without pictures? The saying goes "A picture is worth a thousand words", which was quoted in the early 20th century several times. Another quote "I hear and I forget, I see and I remember….". The University of Iowa conducted a study that eluded that our auditory memory is significantly shorter and inferior to our visual memory. The study concluded that exposure to visual stimuli for a period of 32 seconds render the observer able to recall over 80% of what they saw, versus hearing, which was at best 60%.[8] Photography has evolved since first experimented with in the mid to late 18th century. The first reliable and most memorable early photography is the Daguerreotype. After French Inventor Nicéphore Niépce experimented with creating still images and coated them with Silver Chloride, he created semi-permanent photographs that could be described as a 'negative" at best. He sought to create a more permanent image, so teamed up with Louis Daguerre, another French artist and inventor, to create the Daguerreotype. Daguerre continued his work after Niepce's death and perfected the Daguerreotype process, and even though it required exposure for an hour instead of a few minutes (later photography methods), and now for a few seconds it was a revolution in creating images.[9]

Figure 4. John Quincy Adams, the sixth US president and first to sit for a Daguerreotype photo. Photo courtesy of website https://www.history.com/news/john-quincy-adams-early-photo



Photography has gone through several revolutions over the years. I still remember watching my father load the camera, being careful not to expose it for too long. After the camera had used all the film, you removed it and took it to be developed, usually at a pharmacy or camera shop. I marveled at the Polaroid camera, which developed its own pictures instantly. Now everything is digital, and unless you are a professional photographer you probably use the camera on your phone, which can take pictures that do not look professional, but are done very well if developed. No matter how we view pictures, digital, traditional, or professional finish, they create and preserve memories such as weddings, births, graduations, and everyday life.

Instructional Implementation

At first, I considered personifying ROYGBIV myself and having the students read his "biography" and explore his artwork; but I feel that the students will be more engaged if they get to create Roy G. Biv. It will give them a chance to make him or her into the person they visualize, and therefore giving them more ownership. I will teach the fundamentals of color and light including chemistry, physics, and art history/styles/color mixing. We will do a few experiments and hands on work in class; however, the majority of the student work will be their project. The student will create a person named Roy G. Biv, who can be male or female, and the first name Roy can be short for a longer name. They must give a biography on the person, describing when they were born, their life story, and times that the artist lived in. Students will then detail three experiments their Roy G. Biv performed, which have to involve the chemistry and physics of light (these could already have been done.) the students must perform at least one of the experiments and submit a lab report. For the artistic part of the project, the students must present samples of either art, three paintings, 3 detailed drawings, or a combination of the two; or a photography portfolio that must include at least 30 pictures in different finishes (black and white, sepia, cyan, etc.) The student must stick to the time in which they created their artist. For example, if they decide that Roy G. Biv lived during the Renaissance period (~1300-1600), they cannot include modern art such as photography in their project.

The class will be broken up into two main units, and each unit will have two sections. The main units are The Science of Light and the Art of light. The subunits in the Science unit will include the Chemistry/Physics of Light and the Biology of Light. The subunits of the Art unit will include Painting/Color blending and Photography. Each unit will have several quizzes in the subunits (3-5) and one unit test. Labs and quizzes will account for 20% of the final grade, the unit tests will account for 40% and the final project will account for 40%.

Day One

The course will incorporate literacy, since improving literacy is an important common goal throughout CMS. On the first day of the class, I will write the terms ***light, color on the board,*** and have students write down any words or phrases that come to mind they will have two minutes to do so. Afterward, they will have one minute to categorize their terms. They can only have two categories. As a whole group, we will discuss their choices and why they chose them. After the discussion, there will be a short lecture on light and the EM spectrum. The topic will focus on the visible light part of the EM spectrum and the acronym ROYGBIV (red, orange, yellow, green blue, indigo, violet) and what makes this part of the spectrum between 450nm and 750 nm different from any other part of the spectrum. The class will conclude with the reading of Isaac Newton's Letter on light. For homework, students will write a response to Newton's letter as if they were a fellow scientist in that era. See Appendix 2 for full details and day one lesson plan with link to slideshow on light and color.

Unit 1: Science of Light

Sometime during the first few classes, students will take a pre-assessment on light and color, both the science and art of each. The pre-assessment will allow me to measure student learning when I compare it to the post-assessment that they will take at the end of the class. Appendix 3 will have the pre-assessment and post assessment that I plan to use for the class, as well as a sample quiz and other activity rubrics. This unit will focus on science experimentation, a few traditional 'lectures and notetaking' by the student, reading current and historical texts, and scientific experimentation.

Since my first unit is on the science of light, I want to focus on the science of color as well. One of the most important concepts a student can learn is that black and white are not 'colors' because they do not have a specific wavelength measurement. All the visible colors of light red, orange, yellow, green, blue, indigo, violet (ROYGBIV) have a specific range on the EM spectrum (example, red is between 635 and 700 nm, yellow is 560-590 nm). White light or color is a combination of all the colors reflected and black is the absence of color or light because all the colors are absorbed. To prove this, we will do two brief activities, paper chromatography of black ink and shining white light through a prism. See Appendix 4 for information on these activities and others (teacher resources).

Another activity, which promotes literacy in the classroom, will be to read an article of the history of Roman Glass and the chemistry behind it. The student will use the literacy strategy of Talking to the Text (T4 or TttT) to analyze the work and fully understand it. The questions will focus on the subject, Roman Glass, and the science behind it. The teacher's version of the article includes some focus questions and teachers are free to add additional questions. See appendix four for the article and T4 resources. Some of the other activities in Unit 1 include:

- Growing a crystal garden to study color and light (Reflection, refraction, transmission)
- Virtual Lab: Which colors of the light spectrum are most important for plant growth? (after lecture on photosynthesis “Light is Life”)
- Testing Vision Perception of the eye (after “Can you see me?” (A lecture on the eye and how light plays a major role in sight.)

After each “lecture” (Introduction, Bending and twisting light, light is Life, and Can you see me.) There will be a short assessment of 4-7 questions to be sure students can demonstrate that they understood the lesson and have mastered the content. A sample quiz can be found in Appendix 3 and instruction for all these activities can be found in Appendix 4. At the end of Unit 1, there will be a unit test.

Unit 2

The second unit will discuss art. We will start with a writing exercise. I will display the painting “Starry Night” by Vincent van Gogh, painted in 1889. I will have the students’ list words or phrases of how the art makes them feel. Then I will do the same for the painting “Mountain Top Sunrise” by Sharon Duguay, painted in 2015. The students will then compare their words and phrases for each in a “Think, Pair, and Share” partner activity. As a whole group, the class will discuss their impressions of each painting, if they were the same or different, and why.

“Starry Night” Vincent van Gogh[10]

“Mountain Top Sunrise” by Sharon Duguay[11]

The next activity in the art unit is a very brief lecture on primary and secondary colors. I want to spend the majority of the first few days of the unit discussing the purpose of art and whether art is “needed” or not. Two texts that the students will be reading are the poem “Colors” by Shel Silverstein and the book *My Many Colored Days* by Dr. Seuss[12]. Art History is too great a subject to encompass so I will focus on colors and interpretations in paintings and the second half of the unit will be on photography. One major activity I want to do is to observe how different mediums of paint (watercolors, acrylic, egg tempera, minerals, and oil) will fix to a canvas. I will have the students use these different media to make a brush stroke with each on the same canvas and observe the effect of the paint when it dries. See Appendix 4 for how to mix mineral and egg tempera paint. Each day when the students come in to class, there will be a different painting/or photographs to interpret. This will expose the students to many types of art. See Appendix 4 for more suggestions on art pieces to interpret for warm ups.

The second half of the art unit will focus on Photography. We will start with a history of photography and the basics of capturing a still image. This will be one of the 'mini lectures' delivered for the art unit. The students will also experiment with creating imprint photographs such as the cyanotype (see appendix 4 for where to purchase a cyanotype kit). We will also have a formal debate over which type of photography is 'better': digital or film. The class will be divided into teams, one for the digital photography and one for the film photography. Each team will elect three people to speak. Three different students from each team will deliver the main argument, rebuttals, and closing arguments/questions. Every student on the team will have a role; other positions include researchers, image sources, and speechwriters. See appendix 4 for a document on how to set up a class debate. After all, of these activities, there will be a unit test for the art unit and then students will present their projects.

Final Project

For a final project, students will bring the visible spectrum ROYGBIV to life in the form of a person. Roy G. Biv. The person could be a man or a woman. The student will create a biography of that person, detailing some of their experiments with light and their artistic work. The experiments that the students choose to write up can be ones that they made up or ones that have previously conducted, in which they repeat to verify the results. They will share these experiments in a letter to a journal, similar to the letter Isaac Newton penned to Philosophical Transactions in 1649. The students' letters will represent the time that they choose for their artist to exist. If the student's artist/scientist is contemporary, then the submissions can be typed. If they lived before the invention of the modern typewriter in 1874, they must write it.

For the artistic side of the project, the student must submit original artwork pieces. They can either submit three paintings done with any pigment other than watercolor or 30 photos. The photos must be a combination of digital and film. There must also be different finishes such as sepia, black and white, glossy, matte, etc. One picture must be a cyanotype. The student will present their Roy. G. Biv to the class with a slideshow, Prezi, video, or poster. After everyone has presented, there will be a show, set up in a gallery where the public can view their projects and the students have a chance to present to the public.

As far as course grading unit 1 coursework and test will count for 40%, unit 2 coursework and test will count for 40% and the project will account for 20% of the student's final grade in the class. This setup is similar to the English 3 and English 4 classes, where the senior exit project counts for a substantial part of the final grade. These combined aspects of the class, the art, science, and final project will give students a better understanding and appreciation for something we often take for granted- light.

Appendix 1: Teaching Standards

Chemistry (North Carolina Essential Standards)

CHEM 1.1.3- Explain the emission of electromagnetic radiation in spectral form in terms of the Bohr model

- Articulate that this electromagnetic energy is given off as photons
- Understand the inverse relationship between wavelength and frequency, and the direct relationship between energy and frequency.
- Use the "Bohr Model for Hydrogen Atom" and "Electromagnetic Spectrum" diagrams from the Reference Tables to relate color, frequency, and wavelength of the light emitted to the energy of the photon.

Physics (North Carolina Essential Standards)

PHYS 2.2.2- Analyze wave behaviors in terms of transmission, reflection, refraction, and interference

- When waves encounter a new medium, the energy may be absorbed by the molecules of the material, transmitted changing speed (refracted) or reflected from the surface.
- Electromagnetic waves travel at the speed of light, c, in air or a vacuum and slow down as they enter other transparent materials according to the mathematical relationships relating wave speed, v, index of refraction, n, and angle of light measured from the normal: $n=c/v$, $n_1v_1 = n_2v_2$; $n_1 \sin\theta_1=n_2 \sin\theta_2$ = (Snell's Law);
- The angle that light strikes a boundary determines if it is transmitted into another transparent material or reflected;

PHYS 2.2.3- compare mechanical and electromagnetic waves in terms of the following

- how they are produced,
- wave speed,
- type of material (medium) required,
- motion of particles,
- patterns for refraction related to medium,
- reflection,
- interference,
- The Doppler Effect.

Identify sound as a compressional wave and visible light as an electromagnetic wave.

Art (North Carolina Essential Standards, Visual Arts 9-12)

B.CX.1- Understand the global, historical, societal, and cultural contexts of the visual arts.

B.CX.2- Understand the interdisciplinary connections and life applications of the visual arts.

Appendix 2

Lesson Plans

Phillip O. Berry Academy of Technology

2018-19 Rigor Lesson

Class: The Chemistry and Art Behind ROYGBIV

Teacher Name: Erika Williams

Date: Day one of Instruction

Block(s) ☐ 1st ☐2nd ☐3rd ☐4th

EXPECTATIONS *(Post on the board daily)*

NC Standard Number: Chemistry: CHEM 1.1.3 PHYS 2.2.2

Objective (**K**now **U**nderstand **D**o)

Students will know the colors of visible light. Students will understand how light travels in waves and the EM spectrum. Students will read Isaac Newton's letter on light and write a response to the letter as a scientist.

Essential Question(s)

What makes unique from all the other types of radiation on the Electromagnetic Spectrum (EM)? What characteristics of light make it so useful in art and science? How does light travel.

LEARNING PLAN

Activities (for whole group, small groups, an individual)

Free writing from two prompts *light* & *color* . Students think pair share, then share out with the whole class for a group discussion. Students will Cornell Notes on a presentation given by the teacher on light, photons, and the EM spectrum. Presentation can be accessed here → https://goo.gl/CLuf7V

Pre-Determined Questions (check for understanding and adjust immediately)

Click or tap here to enter text.

CHECK FOR LEARNING

Written or Verbal **Performance Task**(s)

Reading Isaac Newton's letter on Light to the Journal of Physiological Transactions of the Royal Society, 1672. Students will pen a response to Newton as a scientist, Roy G. Biv.

Appendix 2

Assignment Description: Letter to Roy G. Biv

In class, we read “A Letter of Mr. Isaac Newton on light and color”, which discussed Newton’s findings and preliminary experiments of color and light. For the time (1671), these discoveries were revolutionary. **Your Task:** You will pen a response to Mr. Isaac Newton as Roy G. Biv, a local scientist and artist. Your letter must contain three things: 1. Praise for Mr. Newton’s work. 2. A follow up question on his work or part of his work. 3. A recent conclusion about light of your own (can be anything not mentioned by newton in the letter). The typewriter was not invented until 200 years later, so you will write the letter on unlined parchment paper provided by the teacher. Must be in black ink. Your writing must be in cursive. If you need help writing in cursive, I will hold a writing clinic after school.

Due Date: Three Days from now. See rubric below.

Rubric: Letter to Isaac Newton

Category	**Points Possible**	**Points Awarded**	**Comments**
Content: Letter fulfills 3 requirements Of praise, question, and recent discoveries/experiments	60 (20 per requirement)		
Mechanics: Written on Correct Paper, Cursive, and In Ink	30 (10 per requirement)		
Authored as Roy G. Biv	10		
Total Points	100		

Appendix 3

Assessments and Rubrics

Pre/Post assessment

https://goo.gl/zGHiaU

This is the assessment I give before I teach the class to measure students' prior knowledge on the subject. I also use this as the post assessment.

Sample Quiz

https://goo.gl/QJJi8J

This is what one of my quizzes to check for understanding and mastery would look like.

Mini Lecture-Light is Life

https://goo.gl/LifBcU

Discusses photosynthesis and other ways that life gives or improves life.

Mini Lecture-Capturing Light

https://goo.gl/tTqLTx

Discusses the history and science of photography.

Day One Lecture

https://goo.gl/CLuf7V

Introduction to light and the EM spectrum. For use with first lesson.

Final Project Description and Rubric

https://goo.gl/kaXGfY

A description of the final project, how it should be completed and a point breakdown.

Appendix 4: Teacher and Student Resources

Paper Chromatography

https://owlcation.com/stem/What-is-Paper-Chromatography-and-How-does-it-Work

A description of paper chromatography and a quick lab to demonstrate results of paper chromatography.

Using a Prism

https://sciencing.com/make-rainbows-prisms-6281318.html

Gives several examples of how to use a prism.

Article on Roman Glass (includes pdf version)

http://www.rsc.org/learn-chemistry/resources/art/resource?sID=RES00001962

This article discusses the art, history, and chemistry involved in Roman Glassmaking. The science behind colored glass as well as reflection and absorption is discussed.

Close Reading resources

https://rtc.instructure.com/courses/1056743/pages/talking-to-the-text

http://reyburngaede.weebly.com/uploads/1/2/4/1/12415771/how_to_talk_to_the_text.pdf

These pages discuss examples of close reading, specifically talking to the text, and its impact on student literacy and why it should be used in every classroom.

Growing a Crystal Garden

http://www.rsc.org/learn-chemistry/resources/art/resource?sID=RES00002019

Students use common mineral salts found in chemistry stockroom to grow crystals of different colors with different reflection and absorption properties.

Carolina Visual Perception Kit

https://www.carolina.com/physiology-kits/carolina-visual-perception-kit/694527.pr

Contains several experiments on the using the eye and how it sees and interprets light. Also a great tool for an anatomy/physiology class.

Virtual Lab on Photosynthesis (Glencoe Science)

bit.ly/pholab

A virtual lab on photosynthesis that allows you to change the color of light to figure out which color of light helps plants grow the most. Will answer the question "Why are plants green?"

How to create paint from minerals

http://www.rsc.org/learn-chemistry/resources/art/resource?sID=RES00001951

Using mineral compounds to create paint.

Egg Tempera

https://www.instructables.com/id/Egg-Tempera-Painting/

Creating paint using egg yolks. Da Vinci used egg tempera to paint the *Last Supper* on plaster.

Class Debates

http://www.teachhub.com/classroom-activities-how-hold-classroom-debate

A guide to having a class debate that will maximize student learning on the topic.

Cyanotype

https://www.jacquardproducts.com/cyanotype-set/

This website sells a cyanotype kit and contains details on how to make a cyanotype. Very useful, even if you do not buy the kit from this site.

Annotated Bibliography

Bedrosian, TA, and Nelson, RJ. “Timing of Light Exposure Affects Our Mood and Brain Circuits.” *Journal of Translation Psychology* 7 (January 31, 2017).
An article on how light affects our mood and hormone levels.

Bigelow, James, and Amy Poremba. “Achilles Ear? Inferior Human Short-Term and Recognition Memory in the Auditory Modality.” *PLOS One*, February 26, 2014. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0089914.
An article discussing the memory of hearing versus seeing in color.

Gernsheim, Helmut Erich Robert, and Andy Grundburg. “History of Photography.” *Encyclopedia Britannica*. Encyclopedia Britannica, Inc., February 1, 2018. https://www.britannica.com/technology/photography.
An article discussing the history and major breakthroughs in photography.

Masters, Alina. “Melatonin, the Hormone of Darkness: From Sleep Promotion to Ebola Treatment.” *Brain Disorders and Therapy* 4, no. 1 (February 2015).
Journal article discusses the role of light and melatonin in the human circadian cycle.

Newton, Isaac. “A Letter of Mr. Isaac Newton, Professor of Mathematics at Cambridge University, on His New Theory on Light.” *Philosophical Transactions* 8, no. 6 (January 1671): 3075–87.
Letter published by Isaac Newton in 1671 detailing his experiments on light.

Pais, Abraham. *Subtle Is the Lord: The Science and Life of Albert Einstein*. Oxford University Press, 1982.
Highlights Einstein's studies on the speed of light, and how he came up with the formula $e=mc^2$.

Seuss, Theodore. *Green Eggs and Ham*. Random House, 1960.
Children's classic demonstrating that color plays a factor in food preference.

Seuss, Theodore, and Johnson, Steve (Ills.). *My Many Colored Days*. Knopf Books for Young Readers, 1996.
Children's classic on color exploration.

Sharon Duguay. *Mountain Top Sunrise*. March 18, 2015. Oil on Canvas.
Painting depicting bright colors. Can be used as a writing prompt in the art unit.

“The Influence of Colour on Memory Performance: A Review.” *The Malaysian Journal of Medical Sciences* 20, no. 2 (March 2013): 3–9.
Journal publication discussing how color influences memory and learning.

Vincent van Gogh. *Starry Night*. June 1889. Oil on Canvas.
Painting depicting dark colors. Can be used as a writing prompt in the art unit.

Wacker, Matthias, and Holick, Michael. “Sunlight and Vitamin D: A Global Perspective for Health.” *Dermato Endocrinology* 5, no. 1 (January 1, 2013): 51–108.
Journal publication discussing how the body uses sunlight to make vitamin D.

Endnotes

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[1] Seuss, Theodore, *Green Eggs and Ham*.
[2] "The Influence of Colour on Memory Performance: A Review."
[3] Pais, Abraham, *Subtle Is the Lord: The Science and Life of Albert Einstein*.
[4] Newton, Isaac, "A Letter of Mr. Isaac Newton, Professor of Mathematics at Cambridge University, on His New Theory on Light."
[5] Masters, Alina, "Melatonin, the Hormone of Darkness: From Sleep Promotion to Ebola Treatment."
[6] Bedrosian, TA and Nelson, RJ, "Timing of Light Exposure Affects Our Mood and Brain Circuits."
[7] Wacker and Holick, Michael, "Sunlight and Vitamin D: A Global Perspecitive for Health."
[8] Bigelow and Amy Poremba, "Achilles Ear? Inferior Human Short-Term and Recognition Memory in the Auditory Modality."
[9] Gernsheim and Andy Grundburg, "History of Photography."
[10] Vincent van Gogh, *Starry Night*.
[11] Sharon Duguay, *Mountain Top Sunrise*.
[12] Seuss, Theodore and Johnson, Steve (Illust.), *My Many Colored Days*.