# Color the Universe

Pedagogy Option 1: Project-Based Learning

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## Abstract

This paper investigates the pedagogy components of Project-Based Learning (PBL). The Hubble Sight/Insight: Color the Universe lesson plan is being examined as a strong example of PBL. This plan is evaluated based on its alignment to the PBL process, usability in the classroom and relevance to the Science Technology Engineering and Math (STEM) courses that the author is teaching to high school students. The information collected in this study will be used as a basis for lectures conducted by the author to high school students in grades freshman through senior year. The "5E" instructional model introduced in the NASA Endeavor STEM Methods course and reinforced in the Astronomy and Space Science course is being utilized as the PBL process.

Color the Universe

Pedagogy Option 1: Project-Based Learning

"Learning is active. It involves reaching out of the mind. It involves organic assimilation starting from within. Literally, we must take our stand with the child and our departure from him. It is he and not the subject-matter which determines both quality and quantity of learning" (Dewey, 1902). John Dewey, an educational philosopher at the turn of the 20th century penned these words which embody project-based learning. Project-based learning (PBL) involves the active engagement of students, individually and as a group. Through the alignment of lesson plans to the PBL process, students are able to actively construct their knowledge of the subject being presented. A rubric outlining expectations and required elements will be distributed and discussed before the lesson begins.

**The Project-Based Learning Process**

The NASA Project-Based Learning Programs offer a unit plan entitled, "Hubble Sight/ Insight: Color the Universe" (NASA, 2014). The Color the Universe plan is divided into six activities. The first activity of Color the Universe contains a lesson plan to "Make a Digital Camera". For the purposes of this PBL investigation, the "Make a Digital Camera" is being examined as a strong example of the PBL process. Most high school students are very familiar with digital cameras. The culture of smart phones places a digital camera in the hands of teenagers practically every waking moment. Since I will be covering iOS App Writing in my Programming course, this is a valuable lesson plan to conduct with my students. Before they produce code activating the iPhone and iPad cameras and judge the resulting pictures, I want them to know the scientific and engineering aspects of the camera that they are using. The "5E"

instructional model introduced in the NASA Endeavor STEM Methods course and reinforced in the Astronomy and Space science course is being utilized as the PBL process. While conducting this lesson plan, I will have each team of students take pictures of each step with their iPad cameras. This will facilitate the "evaluation" phase of the 5E instructional model.

**Engage:** The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding. The Hubble Space Telescope's Wide Field Camera 3 (WFC3) charge-coupled device (CCD) is a 16 megapixel array. The WFC3 instrument has two "channels", one for ultraviolet and visible light, the other for "near infrared" light. The first channel contains silicon similar to the students' iPhone cameras. The second channel contains a material called "mercuric cadmium telluride" (HgCdTe). The combination of these two channels gives Hubble a wide range of light wavelengths. (spacetelescope, 2014).

An iPhone 5S contains an 8-megapixel camera based on silicon material. (Apple, 2014). The Hubble's CCD is a photon detector comprised of a thin silicon wafer that is organized into an array of light-sensitive regions that capture light and store image information (Spring, 2014).

The "engage" step presented to the students can be made by drawing a correlation between what they use on earth to take pictures, the iPhone and iPad, and the images that are taken of the universe by Hubble.

**Explore:** The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding. At this explore step, images of the Hubble Gallery can be viewed by the students to gain a perspective of the scope of what we are receiving from Hubble (NASA 2014). Students will choose Hubble images, download copies

and record image credits for later use in the evaluation stage. During this step, the NASA Color the Universe lesson plan suggests that the students make a their own “digital camera”. This will allow the students to construct knowledge about photons, charged coupled devices (CCD) and pixels.

**Part 1: Capturing Photons** In step 1 of this part of the explore stage, the students will build their own single pixel “digital camera” using paperclips hanging from plastic tape over a plastic cup. The paper clips represent electrons potentially collected in the plastic cup that represents an “electric potential well”. Step 2 expands on this concepts by having the students drop a pencil (incoming photon) onto the tape that will cause paper clips to drop into the cup and model electrons being collected in the “electric potential well”.

**Explain:** The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means. The students should now have questions about each of the components of the model. A “think, pair, share” can be conducted so that students can process what they have observed and then collaborate in groups to deepen their understanding of the photons, electrons, and pixel “electric potential wells”. Once the teacher reconvenes the class, definitions can be developed and recorded.

**Elaborate/Extend:** The purpose for the ELABORATE/EXTEND stage is to allow students to use their new knowledge and continue to explore its implications. The Color the Universe now gives the student the opportunity to expand their “camera” to nine pixels and simulate an object being photographed.

**Part 2: Capturing an Image** In this part of the elaborate/extend stage, the students will expand their model to nine “pixels” by placing nine cups in a tight array of 3 by 3. This time, the

tape is removed and a paper "filter" provided with the lesson plan is used to simulate bright and dark spots on an object being photographed. Small holes are cut out in the paper filter to simulate dark spots and large holes to simulate bright spots. The filter is held above the 3 by 3 array and the paper clip "electrons" are poured above the paper falling through to the array below. Correlations can be made by the students of light from "celestial wonders" being photographed and the amount of electrons being collected for the resulting "image".

**Part 3: Reading Out the Camera** In steps 1 and 2 of this part of the elaborate/extend stage, the students will designate a "readout" pixel, in position (1,1) of the cup array, and count the paper clip "electrons" to create a data table of the "electrons" collected in each pixel cup. Based on a formula provided within the lesson, students will color a diagram (using giffy.com) with a 3 by 3 array of nine circles, using graduating colors of white, light gray, dark gray and black. Cups with 11 or more paper clips in it remains white - most electrons, cups with 0 to 3 paper clips is completely black - least electrons. Two counts in between represent light and dark gray. The students have now created their first "image".

**Part 4: How Do We Capture Color?** In this part of the elaborate/extend stage, students must now speculate as to how the Hubble Space Telescope captures color images. The teachers' guide of the Color the Universe lesson plan suggests that the students visit the webpage, "The Meaning of Color in Hubble Images" (NASA, 2014). This website explains that Hubble images are actually a combination of two or more black and white images to which color has been added using red, green and blue filters.

**Evaluation:** The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place. The students have been

taking pictures using their iPads throughout each step of this project. VoiceThread is a podcasting subscription website that I utilize extensively as an assessment tool. VoiceThread allows the students to upload images, create "voiceovers" for each slide, annotate slides using a virtual white board and record voice messages on each other's projects. As a team, the students will choose the best pictures to represent the steps, upload the pictures to a VoiceThread project and complete "voiceovers" and virtual white board annotations on each slide. Each team will view each other's projects and record a voice message on other teams' VoiceThreads about the project.

## Conclusions and Further Study

### Usability in the Classroom and Relevance to Course Content

The Color the Universe lesson plan fit very well with the curriculum that I am covering in the Programming course. This lesson plan has given me an "engineering" element that I needed to have the students construct their understanding of the iPhone and iPad devices before programming begins. I believe that this lesson will give the students a deeper understanding of the "science" of image capture and a correlation to the "big picture" of the Hubble Space Telescope. I plan to extend this lesson to include the next phase of Color the Universe with Activity 2: "Mapping the Electromagnetic Spectrum", and Activity 4: "Cooking with Color". Each of these activities correlate to designing apps using storyboards in iOS app writing. We use color extensively in iOS app writing and the "mixing" of red, green and blue will directly apply to topics being covered. It will prove to be very helpful when my students understand how color is captured and represented.

# References

Apple. (2014, 2014). Compare iPhone. Retrieved June 16, 2014, from http://www.apple.com/iphone/compare/

Dewey. (1902). The Child and The Curriculum (Dover Edition ed.): University of Chicago Press.

NASA. (2014). Hubble Sight/Insight: Color the Universe. Retrieved July 16, 2014, from http://www.agl-initiatives.org/SI/Home.html

NASA. (2014). Hubble Gallery. Retrieved July 17, 2014, from http://hubblesite.org/gallery/

NASA. (2014). The Meaning of Color in Hubble. Retrieved July 17, 2014, from http://hubblesite.org/gallery/behind_the_pictures/meaning_of_color/

spacetelescope. (2014). Hubble's Instruments: WFC3. Retrieved July 16, 2014, from http://www.spacetelescope.org/about/general/instruments/wfc3/

Spring. (2014, 2013). Introduction to Charge-Coupled Devices (CCDs). Microscopy. Retrieved June 17, 2014, from http://www.microscopyu.com/articles/digitalimaging/ccdintro.html