Visual Perception and the HSV Color System: Exploring Color in the Communications Technology Classroom

By Emily Jessee and Eric Wiebe

It is essential for graphic designers, especially high school technology education students, to understand why and how to effectively transform data into graphics to both engage the viewer and communicate information.

Communication technology is an important area in technology education when preparing students for twenty-first century careers. Empowering students to be technically literate in the world of communications means learners know how to create, print, and present graphics. A crucial part of this process is effectively encoding information in a graphic form. Understanding how cognitive and perceptual processes influence how we interpret graphics is a part of this literacy.

Being aware of the cognitive principles underlying visual perception is beneficial to students when designing graphics (Haber & Wilkinson, 1982). Visual perception has a close relation to human memory and establishment of association. The cognitive architectures and processes that determine levels of association of how information is managed by the brain are important. The mind is neither a camera nor a computer, and visual perceptual knowledge is a valuable source of information to strengthen design.
One of the important findings from cognitive and perceptual research is how we process and understand color. Three color models are most commonly used in the production of graphics: red, green, blue (RGB); cyan, magenta, yellow, and black (CMYK); and hue, saturation, and value (HSV). Of these, HSV is the color model that comes closest to mimicking how humans perceive color. A ninth grade student comparing HSV to the other color systems is likely to say it’s easier to know what the end result of a color change will be when using this model.

The VisTE project at North Carolina State University (Clark & Wiebe, 2005; Wiebe, et al., 2006, 2007) has focused on creating units for middle and high school students that use graphics to communicate concepts in math, science, and technology. This project used Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007) as a guide to develop activities that helped students learn how to effectively communicate with graphics. A number of the VisTE activities focus on understanding how to effectively use color models like hue, saturation, and value (HSV). Comparing properties of color through various color models and how graphic communication problems can be solved through color helps teach students to look beneath the surface of a graphic and strengthen their skills in communication. These activities specifically focused on two of the STL standards:

- **Standard 10.** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- **Standard 17.** Students will develop an understanding of and be able to select and use information and communication technologies.

That is, students will engage their knowledge of the cognitive and perceptual properties of color and the technology used to produce color graphics to problem-solve ways of communicating information graphically. The following example project extends these principles and looks at how color knowledge can be developed in the communications technology classroom.

**Project Overview**

A student once commented upon completion of a project that what was seen on the screen was not what he saw on the printed page: “Everything changed.” What happened? Students often discuss how the colors on the screen are not always what appear on paper. What does this mean? Aren’t the colors on the screen the same as the colors from the printer? What would cause a difference?

Color is a very important part of design. Learning how color functions with the tools used in class is essential to communicate true images and products. Color is a powerful element that “can draw attention and produce a strong emotional and psychological impact,” (Prust, 1999). In this activity, students are going to learn how to generate a consistent image throughout the production process. Assessing the image from the monitor to the printer is key to learning how to effectively communicate the intended message. To accomplish this task, establishing a basic understanding of calibrating color through visual perception is needed. Part of this process is understanding “the difference between various color systems.” As Armstrong (2004) states, “Monitors, scanners, digital cameras, etc. deal in visible light,” RGB (red, green, and blue), and should not to be confused with the standard primary colors: red, yellow, and blue. RGB color is called additive because it is created by adding varying intensities of red, green, and blue light to black (on a computer screen this equals no light). Using computer software, intensities usually vary from 255 (full intensity) to 0. If each color channel has 256 variations of red, green, and blue, then over 16 million different colors are possible from these combinations. This range of possible colors comes close to describing all possible visible light colors. In fact, most RGB color-generating technologies (e.g., computer monitors) can only display a subset of these colors, called a color gamut.

Printing, on the other hand, deals in light reflected off of or through inks, which creates a narrower color gamut. CMYK colors are secondary, opposite colors of RGB. Cyan absorbs red light, magenta absorbs green light, yellow absorbs blue light, and black (K) controls the overall level of light absorption. The degree of absorption varies on the amount of CMYK colors that are visible. CMYK is known as subtractive because the colors displayed are the result of subtracting varying amounts of red, green, and blue light.

The range for RGB is a bit different than CMYK. Each path encompasses a different area of the total visible light color gamut. In addition, the conversion from RGB color to CMYK color and vice versa is not exact. This is because neither color system is based directly on how humans perceive color. This information brings about the question, “How does one get the version of the image from the monitor and the one from the printer to match?” The answer is plain and simple: iterative adjustment. Within the realm of colors is another system of color commonly seen in a graphics software color picker (method for choosing image color using a tool that looks like an eye dropper): HSV. HSV (hue, saturation, and value) is the system that comes closest to how we “see” and compare colors. One freshman student alluded in a class conversation that it is an easier color model to understand because one can compare and relate to it; the colors are true to how he sees them. Hue is the rainbow aspect of color, explaining where a specific color lies on the visible light spectrum. Think of hue in terms of a circle where the starting and ending color is red. Red is at 0 degrees, yellow is at 60 degrees clockwise with green, cyan, blue, magenta, and red again. Saturation describes how pure a color is. If a color seems to have no gray in it, then it is said to be highly saturated. The more gray present in a color, the less saturated it is. The value goes from 0, neutral, straight gray color, to 100, strong, pure color. Value is brightness, lightness, or intensity—in other words, how much light is coming from the color.
Description of Lesson

At our high school, students learn about visual perception and the changes between RGB, CMYK, and HSV color systems through a series of lessons leading up to a cumulative project. Students use the lessons to gain an understanding of color calibration (refining colors to be true between monitor and printer) and visual perception and to apply these lessons to a final project. Students are first introduced to the idea of color through paint swatches and looking at monitor and printer images. Students discuss the meaning of HSV and use it to describe the differences between colors on screen versus the printed versions. For the final project, students begin by scanning a headshot photograph. Once the image is scanned, students place the image into an illustration program and begin working. Using various tools in the program, students create a two-dimensional, vector-based image similar to the underlying photograph. Rather than having a bitmap image where every pixel is a different color, the vector-based illustration program creates regions of solid color. This process is often called posterization and requires students to visually interpret the color they are seeing in a region in the photograph and pick a single color that represents the collective perception of this region of pixels. Posterization is, in a way, a scaffolding technique that limits the number of colors and regions in the graphic that the student needs to analyze. Therefore, the student is able to focus on both the essential characteristics of a single color, comparisons of pairs of colors next to each other, and the collective impact of all of the colors in the image or region. When done, students print a first draft of their re-creation of the photo. The next step is to adjust colors with the HSV color model.

Using the HSV scale to adjust color is an efficient way of managing colors for the projects in this class. The colors used in HSV can be clearly defined by human perception, which is not always the case with RGB or CMYK. Matching and sharing colors can easily be done in most medium to high-end graphics software packages. For example, Figure 2 shows a color model dialogue box that allows you to see the HSV, RGB, CMYK color specification simultaneously. In this dialogue box, B(lack) is equivalent to V(alue).

Assessment

Assessments are done informally and formally throughout the entire lesson. Informal assessment through observation is an easy way to see if and how students understand the material. Peer, self, and teacher observations are used in the lesson. Peer evaluation is done almost daily through casual conversation and questioning. Students are to casually ask each other questions, such as how to use a tool or opinions on the look of an object. Teacher observations are also used to evaluate student progression. Walking around the room and being easily accessible.

Figure 2. Color model specification dialogue box from a graphics software package.
cessible creates a comfortable learning environment. Deadlines are another informal type of assessment as students are asked to print what is currently on the screen. Deadlines allow student designers and instructors to see the status of a project.

Formal assessments are more detailed and typically involve a grade. For this lesson, printing the portrait project created in the illustration software generates an artifact for formal assessment. When printed, it is easy to assess color calibration through the hair, eye, and skin color in the illustration. This evaluation is guided by the rubric provided at the beginning of the project (see Figure 4). The rubric outlines a structured checklist of items upon which the evaluation will be based. Also, presentations are a type of assessment since they are graded as noted in the rubric. The presentation also provides the student designer time to explain how hue, saturation, and value calibration were achieved throughout the process of creating the illustration.

**Project Conclusion**

This lesson was designed to investigate color using HSV and better understand how we use graphic technologies guided by our perception of color to effectively communicate the intended message. Students build upon their cumulative knowledge to interpret, evaluate, respond, and produce. Learning the HSV

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<tr>
<th><strong>Hue, Saturation, and Value Project Assessment Rubric</strong></th>
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<tr>
<td><strong>Student Name:</strong></td>
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<td><strong>Block:</strong></td>
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<tr>
<td><strong>Place the score that shows how well you feel that you</strong></td>
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<td><strong>completed that criterion for the assignment.</strong></td>
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| **Criteria 1 – Preparation**  
Student is engaged in introduction and explanation. Photograph is scanned and placed. | 10 - 9 | 8 - 7 - 6 | 5 - 4 | 3 - 2 - 1 |
|--------------------------------------------------------|
| **Criteria 2 – Process**  
Handout is referred to for instruction and clarification. The following are used: blend, gradients, layer, pen, and transparency tools. | 10 - 9 | 8 - 7 - 6 | 5 - 4 | 3 - 2 - 1 |
|--------------------------------------------------------|
| **Criteria 3 – Effort**  
Student used time well during each class period and exhibited consistency, dedication, and patience. Proper cleanup procedures utilized. | 10 - 9 | 8 - 7 - 6 | 5 - 4 | 3 - 2 - 1 |
|--------------------------------------------------------|
| **Criteria 4 – Craftsmanship**  
Color calibration is done with test strips and adjustments of HSV. Portrait is a unique piece with a high level of originality and creativity. | 10 - 9 | 8 - 7 - 6 | 5 - 4 | 3 - 2 - 1 |
|--------------------------------------------------------|
| **Criteria 5 – Presentation**  
Project is done on time. It is matted, neat, clean, and completed on time. Student is participatory and active in discussions and reflection. | 10 - 9 | 8 - 7 - 6 | 5 - 4 | 3 - 2 - 1 |
|--------------------------------------------------------|
| **Total:** 50 x 2 = 100  
**Your Total**  | **Teacher Total**  |
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Figure 4. Rubric for final project.
and previous experience to develop their ability to describe, color system along with the use of color strips is an effective and informative problem-solving method to make iterative adjustments to color when working on graphic communication projects. By the end of this lesson, students are expected to understand the relationship between the three components of the HSV color model in order to accurately calibrate color, produce test strips, and create a final product.

References

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This is a refereed article.