A Student-Centered Interactive Color Quiz

Edward P. Wyrembeck, Howards Grove High School, Howards Grove, WI

This year I wanted to get my conceptual physics students more actively involved in their study of color addition and subtraction, so I decided to develop an interactive color quiz that I could use throughout the unit. I use the electron oscillator model to explain the emission, reflection, and absorption of light at the atomic level. My quiz is an extension of an activity I read about in *The Physics Teacher* on an "Interactive Spectra Demonstration."[1] It requires only some spray-painted tennis balls (red, green, and blue) and whatever color of clothing the students wear to class.

I begin my students' exploration of color by demonstrating the additive properties of light using three overhead projectors to project and add the primary and complementary colors of light onto a white screen. I cover each overhead projection surface with a black film bag with a circular hole cut out of the center of each bag. I place my colored filters over the circular holes cut in the black film bags and overlap the three colored circles on the white screen. This creates a very large and bright demonstration of color addition to experiment with in a dark room. Once I have demonstrated the additive properties of color, I turn off two of the overheads, remove the black film bag from the last overhead, and overlap colored filters of the subtractive primaries (cyan, magenta, and yellow) to demonstrate color mixing by subtraction. These demonstrations provide the students with the basic rules of color addition and subtraction.[2]

The Additive Color Quiz

The next day in class I begin to probe my students' conceptual understanding of color by quizzing them with colored tennis balls. I usually start by explaining that the tennis balls simulate low- (red) and high- (blue) frequency visible light photons, and I will simulate a source of light capable of emitting these different photons/colors. I begin the quiz with color addition by simply tossing out a red, green, and blue ball to three different students and asking the class what color light I am emitting. The students should answer white, and I retrieve the balls. The students like tossing the balls back, so be very alert for incoming pho-

Figs. 1(a)–1(c) Student participating in interactive color quiz.

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tons. Next I toss out a red and green ball and ask the class what color light I am emitting. The students should answer yellow, and I follow this up with cyan and magenta using the same pedagogy. To go a little deeper into the addition of color, spray paint three more tennis balls cyan, magenta, and yellow to produce white, using a primary color and its complement. I always toss out a yellow and blue ball to check my students' understanding of what is meant by a complementary color. If the students respond correctly with white, I am ready to move on to color mixing by subtraction. If the students have difficulty with the complementary colors, turn on two of the overhead projectors and demonstrate the addition of a primary and its complementary color, but be sure to ask the students to explain why this combination produces white. This would also be an excellent time to begin discussing the functions of rod and cone cells on the back of the retina.

The Subtractive Color Quiz

Once I feel confident that my students understand the additive process of color mixing, I begin checking their understanding of the subtractive process. I start by tossing a red ball to a student wearing a yellow shirt. I ask her what color her shirt is when it is illuminated by red light only. I have found that this can be a difficult question for many students to answer. Students have very little experience with sources of light that emit only a single color of light, especially if it is being projected on a different colored object. Almost all the sources of light that they experience on a daily basis emit white light. If my students have difficulty with this question, I guide them toward the correct answer by having the student with the yellow shirt come up in front of the class and projecting a red light on her shirt using one of the overhead projectors. This provides all the students with the visual experience they lack, but it does not explain their observations. Therefore, I ask the students to explain what they have just observed from an atomic (electron) point of view. The students should explain that the electrons of the atoms making up the yellow dye do not resonate to the lower frequencies of visible light and thus reemit the red light as reflected light. Now the student with the yellow shirt should throw the red ball back at me and state that her shirt is red in color (Fig. 1).

If I feel the students have a good understanding of this observation, I proceed to throw a green ball at the same or another student with a yellow shirt and ask her what color her shirt is now. The student should respond by throwing the green ball back at me and declare that her shirt is now green. Next I throw a blue ball at another student with a yellow shirt. If the student understands that yellow is the complement of blue, he should hold on to the blue ball and explain why his shirt is ideally black in color. The student's explanation should stress that the electrons of the atoms making up the yellow dye resonate to the higher frequencies of visible light and thus selectively absorb blue light, creating a dark if not black shirt. I finish this pedagogy off by making the shirt yellow by tossing both a red and green ball to a student with a yellow shirt. The student should throw both balls back and declare his shirt yellow.

This entire interactive quiz can be accomplished in as little as 20 minutes, or it may take a little longer depending on what the teacher discovers about the students' conceptual understanding of color. While I am teaching color, I like to start each class with a short (five-minute) interactive color quiz, picking different students and different colors to explore each new class period. The rules of color addition and subtraction are easily forgotten, but the added experience and understanding of color that students gain by participating in the interactive color quiz is not something they forget when they leave the lab.

Comments

This type of an interactive quiz between teacher and students offers many advantages over a more traditional quiz. First and most importantly, students are actively engaged in the learning process and learn as much, if not more, from their mistakes. This type of a quiz is for the most part nonthreatening to students. There is almost no limit to the number of questions you can generate and it is open-ended. In a unit on color, the teacher can quiz the students for a short time each class period to test their understanding of color, correct misconceptions, and reinforce concepts. The materials needed to produce the quiz cost nothing or very little. The tennis coach donated the tennis balls, the art teacher donated the black film bags and spray paint, and an art student even spray painted the tennis balls for me. In short, an interactive quiz that simulates color addition and subtraction is fun and motivational for both students and physics teachers alike, is easy to create and to modify, and costs little or nothing to produce. If you teach color, I urge you to have some fun with your students and give it a try.

References

1. Bruce C. Palmquist, "Interactive spectra demonstration," *Phys. Teach.* **40,** 140–142 (March 2002).
2. Paul G. Hewitt, *Conceptual Physics*, 3rd ed. (Addison-Wesley, Menlo Park, CA, 1999), pp. 426–431.

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Edward P. Wyrembeck *has been teaching physics and calculus and serving as the science department head at Howards Grove High School in Wisconsin for the past 18 years. He received his B.S. degree from the University of Wisconsin-Oshkosh and his M.A. in Ed. from Marian College of Fond du Lac, Wis. He is currently interested in modeling pedagogy, developing interactive educational websites, and writing journal articles to share with other teachers.*

Howards Grove High School, 401 Audubon Road; Howards Grove, WI 53083; ewyrembe@hgsd.k12.wi.us