COLOR, VISION, AND ART: TEACHING, LEARNING, AND MAKING ART WITH COLORBLIND AWARENESS

By

GRACE W. HO

A CAPSTONE PROJECT PRESENTED TO THE COLLEGE OF THE ARTS

UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

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Artists in today's busy world took time to participate in my research; I thank them for valuable experiences that contributed to my project. I greatly appreciate Dr. Michelle Tillander and Dr. Craig Roland as committee chair and member respectively, for guiding and supporting my research. I attribute the spark for my research topic to Professor Patrick Grigsby: through my work in his sketchbook studio course, I re-connected my interests in science and art in previously unexplored ways. I thank all who offered words of wisdom, encouragement, understanding, and kindness while I worked long hours for the sake of learning. And everyday, I rely on hugs and kisses from my children. Most of all, sharing art and life with my dearest friend Ken Yang makes it sweeter.

ABSTRACT OF CAPSTONE PROJECT PRESENTED TO THE COLLEGE OF THE ARTS OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

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December 2014

Chair: Michelle Tillander
Member: Craig Roland
Major: Art Education

Abstract

One of 12 students in a typical classroom may be colorblind, sometimes unrecognized by the student self, peers, teachers, family members, and society at large. When colorblindness remains hidden, challenges in learning and making art present as color confusions and other communication difficulties between learners and teachers. My research merged scientific with artistic perspectives to explore connections between colorblindness and art education. With a focus on finding strategies to support teaching and learning art for students who are colorblind, I investigated existing approaches in art education and disabilities. In addition, I used a micro-ethnographic approach to study the experiences of living artists who are colorblind and have self-initiated presence on the Internet. My project website https://www.hoyangfineart.com/uf-research.html consisted of two parts: "Learn and Share" includes a summary of recommendations for teaching and learning; and "Make a Difference" highlights artists' insights

for making art in a world where common (typical) color labels dominate. While exploring connections between art education and artists' experiences in support of colorblind awareness, my key findings include: using technology and text within strategies for learning and making art, providing multiple means of learning, and having support to make art with different color vision abilities.

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Dedicated To Process

Sketchbook, black pen, ink and brush, graphite stick, pencil, carbon paper - no eraser.

Scissors, exact-o knife, paper, needle holder, glue, tape - no ruler.

Images, Gray's Anatomy, computer, camera - no plans.

Memories, thoughts, ideas, visions, impressions, observations - no limits.

- **Grace W. Ho**, summer 2014

Introduction

Artists see the world in different ways.

I once taught an art student with color vision deficiency. His mother told me that he likes to draw and that he is colorblind. As I shared painting techniques and color mixing with the class, I felt lost. At the time, I wondered, 'What should I do?' and quick how-to sites on the Internet didn't fill my knowledge gap: I remained lost. With the recent making of my sketchbook (http://issuu.com/ufarted/docs/gracehobook/0) for UF studio work, I thought about vision and wondered, 'What do you see?' I saw the colors of my sketchbook, preferring the monochromatic feel of black ink, grey graphite, and blue carbon imprinting on creamy white pages. But seeing color is just one part of vision. Reflecting on the process of making art, I wondered if what I do will make a difference in how we see color and make art.

Statement of the Problem and Goals for the Study

One of 12 students in a typical classroom may be colorblind, unrecognized by the student self, peers, teachers, family members, and society at large. The social and learning implications of colorblindness often live in hidden spaces as an invisible disability without overt physical signs (Hansen, 2013; Helfand, 1999; Levine, 2013). Art teachers should not feel lost when faced with learners who see colors and art in different ways. My investigations merged

scientific with artistic perspectives to provide contemporary approaches to support teachers and learners in how we see and make art inclusive and beyond common (typical) considerations of color.

With a focus on finding strategies to support teaching and learning art for students who are colorblind, I investigated sources in art education and related discussions on disabilities. I also looked at the experiences of living artists who are colorblind to gain insights about making art in a world dominated by common (typical) color labels. Between education sources and artists' experiences, I assumed connections existed to link colorblind awareness with teaching, learning, and making art. Therefore, I based my research on the questions below.

Research Questions

- What strategies support teaching and learning art for students who are colorblind?
- What insights come from studying the experiences of artists who are colorblind?
- How do strategies and artists' experiences connect colorblind awareness with contemporary approaches to art education?

Rationale and Significance of the Study

Teachers, learners and artists have in common the everyday challenges of trying to communicate, find support, and make connections with others. Finding approaches to art that include methods for all learners could ideally support challenges faced by art students who see colors differently. Investigating colorblindness within the realm of art education and disabilities could provide ways in which to address the hidden nuances of colorblindness.

As an artist who teaches outside of school walls, I see my studio as a shared space for learning with others. London (1994) wrote, "Using the school as its base of operations, community-based art education forays out into the community for its motivation and subject

matter" (p. 4). I believe when teachers look beyond the classroom to include resources found in the community and on the Web, they extend the possibilities of learning into spaces outside of school. Artists who choose to present their art/work online become potential teachers by sharing their lived experiences, having conversations, and showcasing their work with knowledge-seeking audiences as learners. The Web-based community of living artists provides public spaces (e.g. Facebook ®, Twitter ®, Blogger ®, Web-sites, etc.) for dialogue and sharing art and work. The study of Web-based artifacts and artists' experiences supports studio art making and thinking by forming connections between learning in the art room and the art world at large (Hetland, Winner, Veenema, & Sheridan, 2013).

Research Assumptions and Limitations

Based on my personal experiences and interest, I developed my research topic with the assumption that existing knowledge about colorblindness did not specifically connect with art education in supportive and insightful ways. I assumed by studying the experiences of living artists who are colorblind, I could find ways to make significant connections between colorblind awareness and teaching, learning, and making art. The intent of my research was not to provide evidence of artists' colorblindness (i.e. I did not ask for proof of diagnosis, type, and severity), nor was it to analyze artists' abilities and define success. In essence, I assumed that the responses provided by artists who chose to participate in answering my research questionnaire consisted of testimonial truths for making art with their expressed color vision abilities.

I assumed other artists' experiences (on and off the Internet) existed beyond my research findings; my research was limited to the number of artists who volunteered to participate. I assumed that my collection of artists (see Appendix A) would provide a snapshot look at artists who chose to share what they do with the Internet public. Inherent to qualitative inquiry, I

accepted the non-quantified and assumed truths presented within the personal art and work accessed on the Internet and the written responses provided by artists as research evidence. Given the constantly changing nature of virtual information, I assumed that viewers who use my final research findings will review Internet content that I provided before sharing with learners, keeping in mind appropriateness of content relative to system standards (i.e. norms). Given these research assumptions and limitations, I used my research findings to put forth recommendations for teachers to consider, using strategies and insights that connect colorblind awareness with art education. The significance of these recommendations within the context of use by teachers and learners would require investigations beyond the scope of this research.

Literature Review

My literature review for this Capstone project focused on colorblindness and connections with visual art education. Using the terms *colorblindness (color blindness), art, artists, and education* I found some open access Internet sources related to my topic and artists who are colorblind (see Appendix A for resources). I also searched University of Florida's online libraries (George A. Smathers) with additional terms *color vision deficiency,* which reduced my search results from over 40,000 to roughly 12,000. Use of other related terms (e.g. perception, aesthetics, vision, teaching, special needs, disability) further refined my search. In all, my sources spanned several disciplines (science, medicine, vision, design, technology, special needs, disabilities, and art education) to provide background knowledge from which to build connections.

Definition of Terms

Normal and related terms.

Refer to Appendix A for resources related to terms and definitions. In a world of multiple disciplines *normal* is defined by system standards. Discussions within a discipline often include specific terms relative to normal. Specific terms did not preclude use across disciplines; overlaps existed. The term *disorder* in medicine applies to diagnosis. The term *deficiency* in *color vision deficiency* applies to scientific and medical inquiry. *Disability* relates to institutions and occupations where passing a *color vision test* may be considered essential for specific functions. The common use of *difference* de-emphasizes the comparative nature of specific terms relative to normal. Kasten (n.d.) recommended focusing on strengths and challenges of a "very wide range of variability in the human brain" (para 4) as middle ground. The terms *common* and *typical* relate to that middle ground where humans set (unwritten) standards assumed by society and culture.

Color vision and visual acuity.

Color vision deficiency (CVD) more aptly describes colorblindness as a medical condition that rarely causes blindness relative to *visual acuity.* The typical eye chart for visual acuity (see Appendix A for eye exams) assesses how viewers identify shapes (e.g. the big E at the top of the chart), not colors. Color vision involves external factors such as light and objects, working with internal factors that begin with the human eye and continue within the brain. (Flata & Gutwin, 2012). Cells in the eye called photoreceptors (rods and cones) receive external data; rods work in the dark and cones work in bright settings. Normal color vision relies on the presence of three types of cones to process light wavelengths: red (long), green (medium), and blue (short). Overlaps in light wavelengths produce the colors humans see.

Visual impairment and disability.

I searched colorblindness relative to students and visual arts education; literature in the areas of special needs and disabilities (Gerber, 2011; Malley, n.d.; Wexler, 2012) did not specify colorblindness as visual impairment. According to the Center for Parent Information and Resources (CPIR), *visual impairment* as it relates to children included the familiar near-sightedness and far-sightedness, and a list of less familiar conditions which did not include colorblindness (CPIR, n.d.); in addition, CPIR explained that the Individuals with Disabilities Education Act (IDEA) defined visual impairment as "…an impairment in vision that, even with correction, adversely affects a child's educational performance. The term includes both partial sight and blindness" (CPIR, n.d., section 8) and does not include colorblindness. However, one health services source noted color deficiency as a "condition can be reasonably accommodated under Section 504 of the American's With Disabilities Act" (Recommended Vision Screening Guidelines for Children Ages 3 and Older, p. 14). Other authors noted the need to address the implications of colorblindness as a visual disability that when hidden and unrecognized (Albany-Ward, n.d.; Hansen, 2013; Helfand, 1999) have significant impact on learning in and out of the classroom setting.

Colorblindness and color vision deficiency.

A simplified view of colorblindness typically defined this condition as a genetic disorder that predominantly affects red-green color vision in Caucasian males (see Appendix A for colorblindness). On the other hand, a complex source such as *Normal and Defective Colour Vision* reviewed by Barbur (2003) reached beyond the scope of this topic. Between simple and complex existed necessary knowledge to support awareness that colorblindness affects people of all ages, both genders, in varying types and severity, and with global presence.

Genetic and acquired color vision deficiency.

Flata and Gutwin (2012) described two general types of color vision deficiency (CVD): genetic and acquired. Colorblindness may be acquired when non-genetic factors (such as aging, accidents, disease, and exposure to certain chemicals) cause changes in color vision. Acquired factors tend to affect adults more often than young learners. Genetic CVD occurs when inherited genes cause variations in how cone photoreceptors work. Cones for one, two, or all three visible light wavelengths may be affected; rarely the function of all three cones is completely absent (i.e. achromatopsia). Sex-linked (x chromosome) recessive inheritance of an affected gene from a female results in red-green deficiencies in her male offspring (~8% of Caucasian males). A female offspring with colorblindness (<1%) will inherit red-green deficiencies from the combination of affected maternal and affected paternal genes. Variation in chromosome 7 (Neitz & Neitz, 2011) has dominant inheritance; one affected chromosome 7 from either a male or female source alters blue-yellow vision in the offspring regardless of gender (non-sex-linked inheritance). Various organizations and associations (see Appendix A) provided online information about colorblindness for public access.

Color theory and colorblindness.

Sources across disciplines addressed how people see color and understand color vision (Flata & Gutwin, 2012; Landa & Fairchild, 2005; Lotto, Clarke, Corney, & Purves, 2011; Neitz & Neitz, 2011). The colors that humans perceive vary by values (lightness-darkness), hues (color), and chroma (how much hue differs from neutral gray) as described by artist Albert Henry Munsell in the 19th century (Landa & Fairchild, 2005).

People perceive different colors when light wavelengths in red, green, and blue frequencies combine to make the various colors we see; thus people with common (normal,

typical) color vision are known as *trichromats* (three-color vision: red, green, blue). Partially or completely affected genes alter color vision with the following root classifications: protan (referring to red), deuteran (referring to green), and tritan (referring to blue). People who see with partial color shifts are *anomalous trichromats* and have three-color vision with shifts in red-green or blue-yellow. People who see with complete absence of one color are *dichromats* and have two-color vision. Thus dichromats with *protanopia* (absence of red), *deuteranopia* (absence of green), or *tritanopia* (absence of blue) have severe color confusions. *Monochromats* perceive color within one light wavelength. Individuals with *achromatopsia* have complete color blindness and see in black, white, and shades of gray. Figure 1 summarizes types of red-green and blue-yellow colorblindness.

root	**color shifts (-omaly)** (mild-moderate confusions) **i.e. anomalous trichromacy** (3 colors)	**color absence (-opia)** (severe confusions) **i.e. dichromacy** (2 colors)
protan (red)	protan*omaly* (shift in red)	protan*opia* (absent red)
deuteran (green)	deuteran*omaly* (shift in green)	deuteran*opia* (absent green)
tritan (blue/yellow)	tritan*omaly* (shift in blue/yellow)	tritan*opia* (absent blue/yellow)

Figure 1. Types of red-green and blue-yellow colorblindness.

Hansen (2013) noted among red-green color shifts, 50 to 60 percent present as deuteranomals (green, partial), 12 to 14 percent as protanomals (red, partial), 13 to18 percent as deuteranopes (green, complete) and 11 percent as protanopes (red, complete). About 25 percent of affected individuals have severe colorblindness with complete absence of one or more color receptors (Albany-Ward, n.d.; Hansen, 2013). According to the National Library of Medicine (US) blue-yellow color shifts affect males and females equally, occurring in fewer than 1 in 10,000 people; complete achromatopsia affects approximately 1 in 30,000 people.

The reality exists that subtle differences in color vision may go undetected by color vision screening and testing (see Appendix A for color vision screens and tests). Noting the visual, psychological, physiological, emotional, and educational impact of colorblindness as it relates to specific type, degree of color confusion, and age of diagnosis, Helfand (1999) sited literature to support the benefits of early vision screening and subsequent testing to diagnose type and severity of color blindness. In looking beyond colorblindness as predominantly affecting Caucasian males, Hansen (2013) addressed colorblindness as a human condition "around the world" (p. 22) and sited sources that questioned the lower prevalence rates reported for certain populations (e.g. Chinese, Japanese, and Black Americans).

Inquiries into Color, Vision, and Art

Scholars in many fields have investigated colorblindness as a global condition. Medical inquiry explored diagnoses, type and severity, and varying abilities and measures of success of past artists with colorblindness. My virtual (Web-based) inquiry, on the other hand, looked at experiences of living artists who are colorblind and prompted questions to focus on today's teachers and learners. The combination of medical and virtual inquiries formed the basis to making connections between art education and disabilities with artists' experiences as support for teaching and learning with awareness.

Medical inquiry into artists who were colorblind.

Several sources from medical literature provided examples of artists who were colorblind (Cole & Harris, 2009; Hansen, 2013; Marmor & Lanthony, 2009; Pickford, 1964; Raven, Anderson, & Lanthony, 1995). For a historical glimpse, I reviewed three authors who each chose to highlight the experiences of one male artist thought to be successful: Charles Meryon, Clifton Pugh, and Jens Johannsen. Perspectives on mediums and stylistic choices

illustrated some strategies that colorblind artists have used, such as adapted color palettes for painting or choosing to illustrate without color.

Ravin, Anderson, and Lanthony (1995) wrote about 19th century French colorblind artist Charles Meryon (1821-1868). The authors assumed that "artists who become aware of a defect in their color vision will usually stop working in color…[choosing] other media, such as sculpture or print-making, which do not require normal color vision" (p. 403). Research based on the artist's letters and other writings revealed the following about Meryon: he lacked affection from his parents; he illustrated; he studied at the Louvre; and he attempted to paint with watercolors. In order to explain Meryon's success as an artist, the authors proposed the artist used a color palette "essentially made of two colors" (p. 405). The authors commented on the appearance of color confusion in Meryon's art with overlaps in yellow, green, and orange, or blue and purple.

Cole and Harris (2009) made connections between colorblindness and Australian artist Clifton Pugh (1924-1990) who found ways to make art despite his color vision deficiency. By looking at Pugh's art the authors noted that the artist "mostly built the main structure of his paintings on the colours for which he has perceptual confidence, notably brown (for him dark yellow), black, and blue" (p. 425). The authors attributed Pugh's success to his bold imagination, ability as a draughtsman, and sense of design. The authors recommended that optometrists "should not advise their colour vision deficient patients against a professional art career or limit themselves to non-colour art forms" (p. 427).

Marmor and Lanthony (2001) presented the work and commentary of American-trained painter Jens Johannsen (age 62). The authors explored the artist's intentions, difficulties, and style given his proven diagnosis of severe red-green color deficiency. Conversations with the

artist and observations of his art revealed early difficulties with color confusion in daily life and later challenges with painting in color. The authors wrote: "the fact of the matter is that he [the artist] cannot tell us truly what he sees, any more than a normal-sighted individual can explain the difference between green and red to a color-deficient individual" (p. 409). The authors closed with discussion about other artists who also overcame limitations and noted that the art "may not appear 'perfect' as representational art…. many styles are acceptable to serve many purposes" (p. 414).

Virtual inquiry into living artists who are colorblind.

I found information on the Internet about living artists who are colorblind (see Appendix A for partial list of artists and art exhibitions): female and male, painter, photographer, cartoonist, illustrator, sculptor, software designer, animator, and a cyborg. Artists make art regardless of color as race. Artists use strategies to adapt and to express their visions. The collection of artists I found online revealed diversities in artistic styles, mediums used, and lived experiences. Specific art exhibitions in London and Hong Kong that focused on color and colorblindness provided global evidence for promoting awareness. Among the artists I found in my initial search online, two female artists (one American, Laura G. Young and the other Chinese, Lin Ji) made my list as reminders to look beyond simplified statistics of Caucasian and male.

Across disciplines, I found significant inquiry into color, vision, and connections with art and artists. Past artists used adaptive strategies such as limited color palettes or chose not to use color-based media. Today's artists and the variety of their art and work displayed online sparked my interest to find contemporary approaches and strategies that could take color and art beyond limited paint palettes or choosing specific media to avoid color. Reviewing medical and

virtual sources provided evidence that artists have and continue to see color and make art in different ways; my research questions aimed to find contemporary approaches to connect colorblind awareness with art pedagogy.

Implications of Uncovering Strategies and Providing Choices

The social and learning implications of colorblindness often live in hidden spaces, sometimes by choice (not wanting to seem different), sometimes by strategic adaptation (not needing differentiation), and perhaps for other reasons. When colorblindness remains unrecognized, challenges in learning and making art present as color confusions and other communication difficulties. Simplified views about color vision deficiency lead to misunderstandings and misconceptions of how we see color and art.

The concept of *seeing* has meanings beyond the literal mechanics of sight. At the root of making art is seeing beyond sight to include other factors such as perceptions, emotions, and cultural and societal contexts. Berger (1972) wrote, "The ways we see things is affected by what we see … We never look at just one thing; we are always looking at the relation between things and ourselves," (pp. 8-9). Therefore, I explored the notion of *vision* beyond the science of sight to include the human and artistic qualities of seeing. Inquiry that blends science and art is not new (Eisner and Powell, 2012). Although I did not find literature that specifically connects the science of color vision deficiency with art education relevant to today's learner, I envisioned further investigations into education sources and the experiences of living artists as a means of extending my research in contemporary directions.

Methodology

Although I noticed a gap in literature to specifically connect colorblindness with art education, I assumed that connections existed within discourses on student disabilities, design

and technology, and universal awareness. I used qualitative inquiry and a micro-ethnographic approach (Stokrocki, 1997) to gather evidence from art education and disabilities sources, artists' experiences, and my own work in the field using technology. My data collection and analysis of approaches to art and artists' experiences spanned approximately eight weeks, overlapping with time in the field during which I used technology and worked on presenting my art and work online. I envisioned evidence from contemporary approaches and artists' experiences would provide multiple perspectives beyond descriptions of a singular point of view.

Data Collection from Three Sources

From my literature review, Lotto et al. (2011) noted misconceptions about color and emphasized variations in color vision, normal and deficient. Lotto et al. (2011) wrote, "what we see is not always what is there…a phenomenon we call illusions" (p. 262). The notion that people see colors in different ways is further supported by various online sources (see Appendix A for color and light, colorblindness). How art students see color and make art depend on learning environments that provide support in multiple ways. Therefore, I looked for strategies for art making that could support all learners including students who are colorblind. I gathered evidence from three general areas: art education and disabilities, artists' experiences, and my own work in the field.

Data collection from art education sources.

The school art classroom is one of many possible environments for learning (London, 1994). As a practicing artist who shares knowledge with learners in non-school settings (e.g. private lessons in my studio art room, programs and projects within my community), my approach to teaching art provides experiences outside of school. Therefore, I found broad-based

and flexible frameworks with existing strategies that aim to meet the needs and interests of different students, applicable in different settings.

From art education sources, I looked at existing approaches that included discussions on student disabilities and inclusion of differences. I found provisions in the new Visual Arts Standards of 2014 (i.e. NCAS, National Core Arts Standards http://www.nationalartsstandards.org) and principles of Universal Design for Learning (UDL, from the National Center on Universal Design for Learning http://www.udlcenter.org/aboutudl). As discussed in data analysis later, the National Core Arts Standards' (NCAS) provided definitions for t*echnology* and *text* and new vocabularies within assessments to support different ways of teaching and learning. Principles of UDL emphasized reasons for providing multiple means to address the "what, how, and why" of learning by different students.

Data collection from artists' experiences.

Self-initiated artist statements and artifacts online exist as unsolicited and available information for study. I reviewed published auto/biographies, news stories, videos and images of art on the Internet (e.g. Websites, blogs, social media interfaces, etc.) and collected over 20 Web-links as resources (see Appendix A for partial list of artists and art exhibitions). To gain further insights from artists, I devised a questionnaire (see Appendix B for participation documents) to gather evidence about artists' backgrounds, early memories, and strategies for making art. I submitted my application and received university Institutional Review Board (IRB) approval prior to conducting my research using the participation documents.

By email or Web contact page, I introduced myself to 13 artists and then sent participation documents to seven artists who replied with interest. At the end of my three-week timeframe to collect questionnaire responses from artists, I received informed consent forms

and voluntary responses from four artists. All four participating artists allowed use of their names and open access information along with their responses for my research (https://www.hoyangfineart.com/make-a-difference.html).

Data collection from my fieldwork.

Flata and Gutwin (2012) wrote about the frustrations with communication among friends and family members of people with colorblindness. The authors studied and reported on the benefits of better understandings when people use simulation tools to approximate the colors seen as different. The authors noted that people with colorblindness would benefit from improved accessibility and use of personalized simulation domains as assistive technology. Torrents, Bofill, and Cardona (2011) reported findings related to learning when students with colorblindness felt anxious and disappointed due to misinterpretations about difficulties and challenges. The authors investigated school textbooks, found difficulties in color discrimination for learners, and made recommendations for editorial boards to consider alternatives in design.

I found public online sources that provided how-to steps for teachers to take in supporting students with colorblindness (see Appendix A, colorblindness) such as using good lighting, providing supplies with identifying color labels, writing with white chalk instead of color chalk on blackboards, and pairing learners with peers to help identify colors. However, quick how-to sites did not include ways for the *learner* to take active steps towards independent work with the potential benefits of using assistive technology. Furthermore, I did not find discussions about contemporary approaches to teaching, such as using new vocabulary within assessments (e.g. NCAS' Model Cornerstone Assessments). Therefore, to consider the art room environment beyond attending to supplies and reliance on teachers/peers for support, I looked

for evidence for the use of design and technology within strategies for teaching and learning art for students who are colorblind.

For my own fieldwork, I searched the Internet for design tools, software, and applications that addressed color, vision, and colorblindness (see Appendix A for design and technology). From many that were available, I chose a smartphone simulation application (app) that appeared user-friendly towards making classroom modifications. Based on preliminary online product details about its features to simulate colorblindness, distinguish color, and emphasize objects difficult to see, I decided to download and use *ColorDeBlind* (https://itunes.apple.com/us/app/colordeblind-how-color-blind/id513529073?mt=8). I collected images and made comparisons between objects seen as common and color shifted. Sample collections of my images (smartphone camera photos and screen shots) using simulation applications exist as slideshows on my project Website (see Figure 2).

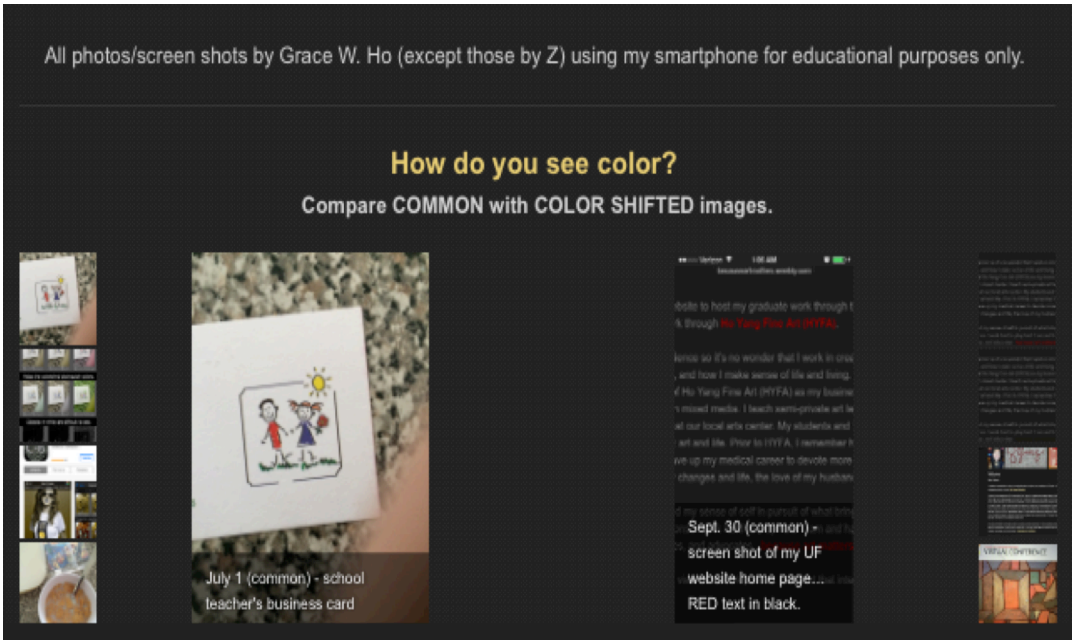

Figure 2. Screenshot of my Webpage "Learn & Share" with two slideshows to compare images using simulation apps.

I used *ColorDeBlind* app to simulate images of what people might see if they had *complete absence* of red, green, or blue color vision (i.e. protanopes, deuteranopes, and tritanopes); the application does not simulate partial color vision shifts that might be seen with anomalous trichromacies. I looked for other simulation applications (see Appendix A for tools, software and apps) and found *Chromatic Vision Simulator* (*CVS*) with its feature to change the "simulation intensity"[1] from 100% down to 0%, original (see Figure 3). During the latter weeks of my research, I took comparative images using the *CVS* app and focused on art and educational materials as subject matter; I included a second comparative slideshow of common and color shifted images on my Webpage "Learn and Share" (see Figure 2).

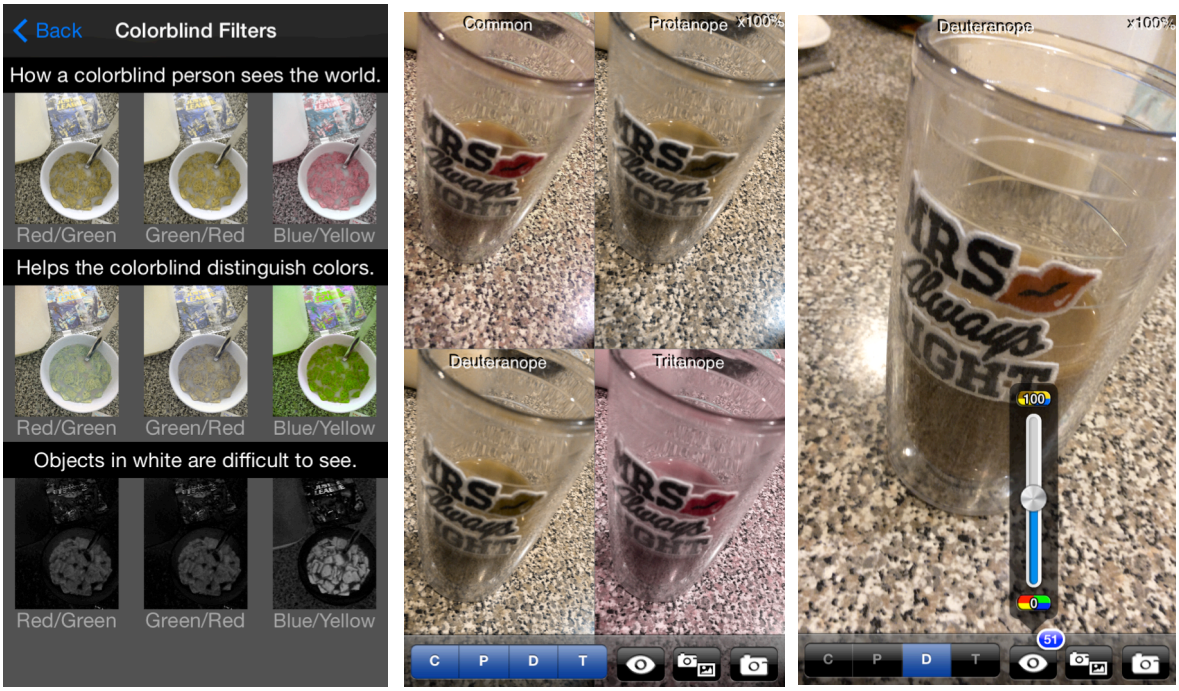

Figure 3. Screenshot images using *ColorDeBlind* app (left) and *Chromatic Vision Simulator* app (middle image showing 100% and right showing 51% intensity).

[1] According to *Chromatic Vision Simulator* user's guide

A color-distinguishing feature on *ColorDeBlind* allows users to simulate identification of colors; this feature has the potential for learners to *approximate* color labels independent of teachers, peers, and other individuals, who may not always be available to support. The colors distinguished by the app varied depending on lighting and possible other colors detected within the app's designated square (see Figure 4); the accuracy of the app in distinguishing colors will vary.

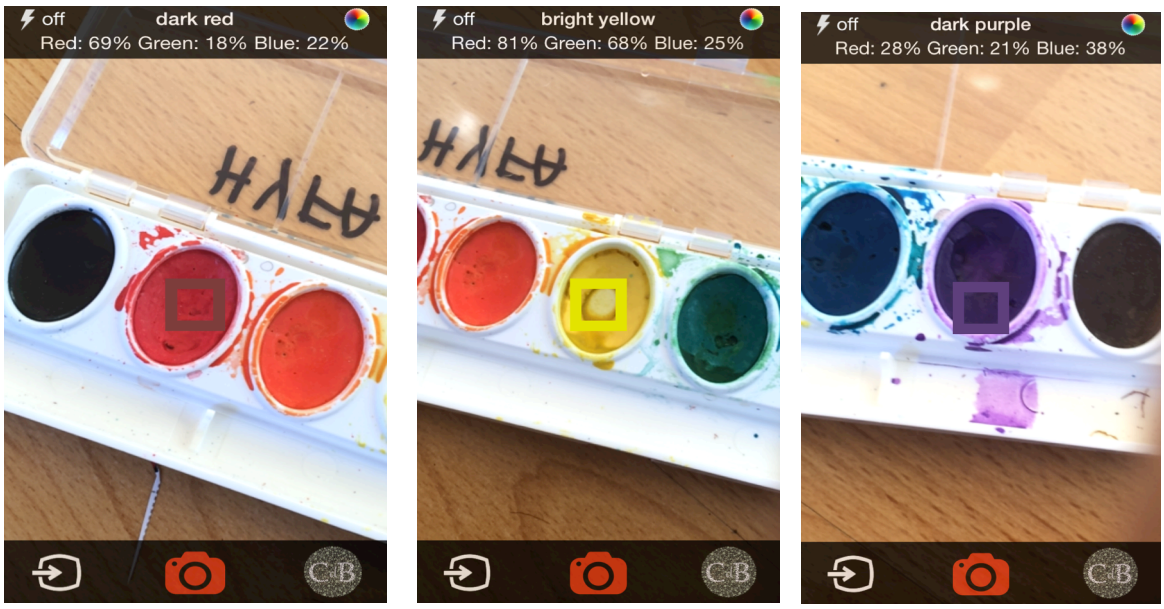

Figure 4. Screenshot images using *ColorDeBlind* app to distinguish colors in a tray of watercolors. Notice the yellow square in the middle image distinguishing yellow (paint) *with* white (bottom of the paint well) as "bright yellow."

Data Analysis from Three Sources

Analysis of data from art education sources.

As a practicing artist who shares art with learners of all ages in my studio art room and within the community, my approach to teaching has not been bound by school related (e.g. district, state, national) education standards. However, I took into consideration existing education standards for teaching and expectations of learners. After attending National Art

Education Association's first virtual conference on September 27 and 28, 2014, I learned more about the voluntary new Visual Arts Standards (NCAS, National Core Arts Standards, n.d.) and its "Web-based Standards Environment that [educators] can customize for use in planning . . . to guide curriculum design and assessment" (http://www.virtualarteducators.org).

The framework for NCAS included options from which teachers and learners may make choices to meet differing needs and interests. Via NCAS' homepage, I found discussions related to "Inclusion" (http://www.nationalartsstandards.org/content/inclusion) and Malley's (2014) guiding principles on students with disabilities. Malley (2014) sited 2012 data from the National Institute on Disability and Rehabilitation Research that showed the prevalence of visual impairment to be 0.4% of disabilities. As previously noted, I did not find evidence that included colorblindness as a visual impairment within art education sources. Although not typically considered a visual impairment resulting in disability, approximately 25% of students who are colorblind may have severe color vision difficulties (Albany-Ward, n.d.; Hansen, 2013) with complete absence of one or more color receptors. In addition, when colorblindness co-exists with other student disabilities and visual impairments, color vision confusions and communication difficulties may affect students' assessments and plans for education needs (Colorblind Awareness, n.d.).

Thinking universally to address individual differences.

In common between using technology and broad-based approaches exist universal principles that address individual differences related to student disabilities. Malley (2014) discussed ways to address students' unique needs and referenced the National Dissemination Center for Children with Disabilities (now CPIR, Center for Parent Information and Resources, listed in Appendix A) for further inquiry. Malley (2014) also noted the framework of Core Arts

Standards as "intentionally broadly stated to allow for a variety of presentations and responses based on individual student needs and abilities" (p. 6). Among guidelines cited, use of principles of Universal Design for Learning (National Center on Universal Design for Learning, n.d.) in designing instruction and materials "so that all students can fully interact with the content" (Malley, 2014, p. 7) would support the use of design and technology tools, software, and applications for learners who are colorblind. Not only could teachers use technology to make modifications in designing content for students, learners who are colorblind could also use technology (tools, software, and apps) independently to interact with content that has not been modified by teachers[2].

Both NCAS and UDL address the use of technology within the framework of curriculum and learning. Included in NCAS' glossary were two terms, *technology* and *text*, that connect with principles of UDL. From NCAS' visual arts glossary:

> Technologies: Tools, techniques, crafts, systems, and methods to shape, adapt, and preserve artworks, artifacts, objects, and natural and human-made environments.
>
> Text: That form which information can be gathered, expanding beyond the traditional notion of written language to encompass visual representations such as paintings, sculpture, diagrams, graphics, films, and maps.
>
> (http://www.nationalartsstandards.org/content/glossary)

From the National Center on Universal Design for Learning website (http://www.udlcenter.org/aboutudl) the three principles of UDL were

> (1) Principle I: Provide Multiple Means of Representation (the "what" of learning)

[2] The benefits of using technology within classrooms would depend on resources available to provide specific tools and teacher/learner dynamics (age/ability of the learner and willingness to teach/learn).

(2) Principle II: Provide Multiple Means of Action and Expression (the "how" of learning)

(3) Principle III: Provide Multiple Means of Engagement (the "why" of learning).

As discussed later in data analysis, when considered together —use of technology and text with multiple means of learning—broad-based and flexible systems have the potential to bridge gaps created by color vision differences experienced by teachers and learners.

Analysis of data from my fieldwork.

As I used simulation apps on my smartphone, I considered the principles of Universal Design for Learning. To address the "what" of learning (Principle I of UDL) with art students, teachers could look at providing multiple means of *presenting information* to include differences in perceptions, language, and comprehension: the use of simulation apps (e.g. *ColorDeBlind, Chromatic Vision Simulator*) to look at text and materials allows teachers to check and compare colors seen as common and color shifted (see Figure 5).

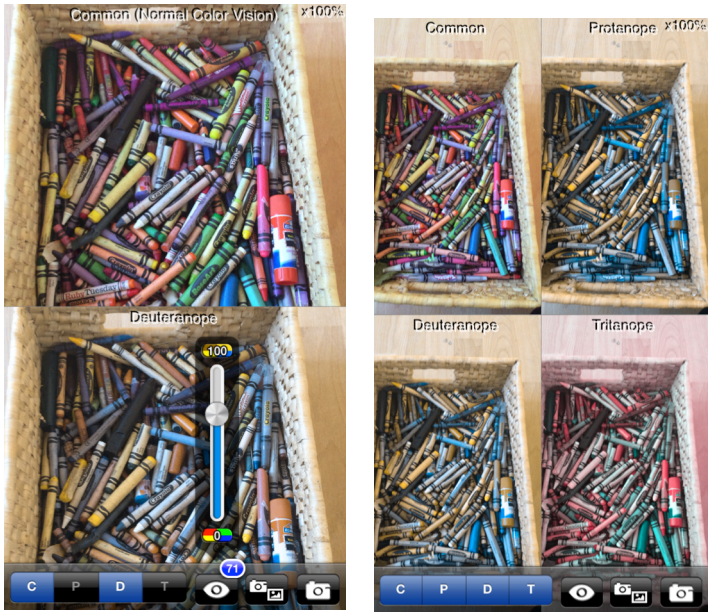

Figure 5. Screenshot split-images using *Chromatic Vision Simulator* app to check color-based materials in my studio art room.

Awareness of possible color confusions prompted re-thinking about making modifications in my studio art room. By looking at a basket of nubby crayons (see Figure 5) with and without identifying labels, I noticed the color confusions that might arise with assignment prompts that ask students to use color-based materials. For a learner with red-green shift in color vision, confusions with red-based colors might appear brown for pink, blue for purple, and tan for orange. Keeping in mind color confusions and provisions for presenting information (i.e. Principle I of UDL), I could modify my studio art room to include multiple means for learning in the following ways: in addition to (or replacement of) the basket of crayons, I could provide other color-based materials with better labels (keeping in mind that labels don't necessarily help in understanding the nuances of individual colors), choices in colors to use for the assignment, the option to pair up with a peer to work on the assignment, other methods for completing the assignment, and/or use of assistive tools such as simulation apps on a mobile device. Showing learners how to use software, tools, and simulation apps could then support independent work with performing tasks and thinking conceptually as they see color and make art.

As I thought about multi-method approaches to curriculum content (i.e. Principle II of UDL), I explored the potential benefits of using technologies and varied text. When teachers consider the "how" of learning through *actions, expressions, and communications* with students, using the web-based structure of NCAS could result in curriculum that incorporates multiple means, new vocabulary, and assistance from using simulation apps.

For example, when I reviewed the National Core Arts Standards' "Model Cornerstone Assessments" (MCA, http://nationalartsstandards.org/mca/visual-arts) for elementary and high school instructional levels, the vocabulary used to describe learning

did not include *color* as an art element within objectives. Instead, *key vocabulary* included tasks such as communicate, compare/contrast, and conceptualize and concepts such as creativity, meaning, and perception. Furthermore, at each level (e.g. grades 2, 5, and 8; high school proficient, accomplished, and advanced), MCA guidelines reminded teachers to look at "Strategies for Inclusion" and "Differentiation Strategies" to take further steps like "Modify tools and materials for use by students with disabilities . . . Provide varying means through which students can express what they have learned" (NCAS, 2014, *Model cornerstone assessments*).

In comparison, National Core Arts Standards (NCAS) differ from the North Carolina Essential Standards (http://www.dpi.state.nc.us/docs/acre/standards/new-standards/arts/visual/k-8.pdf) for art education: North Carolina standards included *visual literacy objectives* like, "Understand characteristics of the Elements of Art, including lines, shapes, colors, and texture" (p. 1) beginning in kindergarten and continuing (with variation) through high school. Furthermore, I could not find related links on North Carolina's Website for visual art standards that address disabilities. Comparing the new National Core Arts Standards with North Carolina's Essential Standards provided evidence that standards differ and suggested that perhaps state standards need updating[3]. The new vocabulary within NCAS' assessments moves learning objectives beyond traditional art elements (e.g. color, shapes, lines) to focus on tasks (e.g. communicating) and concepts

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[3] From North Carolina's Essential Standards "The *Arts Education Essential Standards* incorporate the *National Standards for Arts Education*, which were developed by the Consortium of National Arts Education Associations in 1994, as part of the standards movement defining what every young American should know and be able to do in the arts (http://www.ncpublicschools.org/acre/standards/new-standards/).

(e.g. perceptions) that expect and allow art students to engage in learning and making art in different ways.

Principle III of Universal Design for Learning (UDL) emphasizes the "why of learning" through multiple means of engagement: "In reality, there is not one means of engagement that will be optimal for all learners in all contexts; providing multiple options for engagement is essential" (National Center on Universal Design for Learning, n.d.). With this third principle in mind, using technology and varied text in designing curriculum and modifying learning environments could prove helpful in providing multiple options for art students who are colorblind.

The significance of applying NCAS' standards and UDL's principles to curriculum design that incorporates colorblind awareness extends beyond the scope of this research. However, considerations of how I could re-think teaching art such that learners see colors and art in different ways have begun, as documented in "This is Not RED and Other Color Truths" (https://www.hoyangfineart.com/uploads/1/6/5/2/16529980/ho_redfinal.pdf) and discussed later.

Analysis of data from artists' experiences.

I used a micro-ethnographic approach to study the everyday aspects of contemporary artists found online. Clifford (1990) explored the concept of the *field* as physical or ideal and perhaps nontangible within the travels through history and space. By virtue of their self-initiated presentation of art/work on the Internet, artists choose to interact with a virtual audience. By using "the study of…a slice of everyday reality" (Stokrocki, 1997, p. 34) I investigated the lived experiences of artists within a virtual field of study. The information found online varied in

format, content, and depth relative to what artists chose to share with their viewing audiences (see Appendix A for partial list of artists).

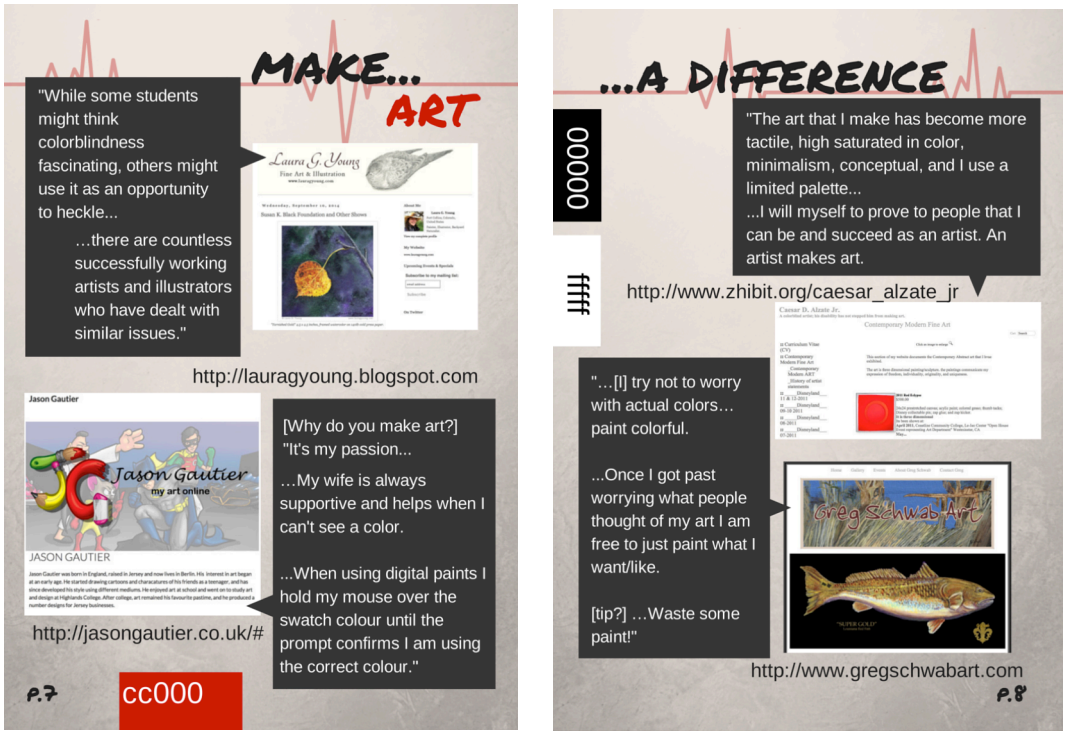

Figure 6. Images of "Learn and Share" slideshow on my project website featuring a selection of responses provided by artists.

Stokrocki (1997) described cross-cultural comparative analysis as a method where propositions lend to a "list of conclusions" (p. 49). Taking note of key categories (Stokrocki, 1997) such as artists' backgrounds, memories of early experiences, and strategies and tips for learning and making art, I looked for commonalities and differences across my data and included a sampling of artists' responses on my project Website page, "Learn and Share" (see Figure 6). In addition, I published a narrative for each participant artist on my project Webpage, "Make a Difference" (https://www.hoyangfineart.com/make-a-difference.html) to highlight his/her online art and work with responses to the research questionnaire.

With permission to use their names, art, and work in my research, I presented evidence, data analysis, and findings by referencing each of the four participating artists with his/her name as follows: Laura G. Young, Greg Schwab, Jason Gautier, and Caesar Azalte, Jr.. Participant artists learned early on of their color vision differences; their art and work online and responses to the research questionnaire provided evidence of how they learned and continue to make art with their color vision abilities. The information collected from several artists using a micro-ethnographic approach provided multiple perspectives beyond descriptions of a singular point of view, such as those provided by medical authors noted previously in my literature review.

Background information and memories.

All four participants were living adult (age range 34 to 48) artists who volunteered to answer my research questionnaire. Although all artists reported selling their art and two artists (Laura and Caesar) noted making art for a living, their responses to how art fits in their lives indicated life-long desires for making art beyond sales: "It IS my life!" for Laura (personal communication, September 29, 2014); "It [art] just comes out – almost compulsive," for Greg (personal communication, September 18, 2014); "It [art] makes me feel fulfilled and I am doing what I was born to do," for Caesar (personal communication, October 3, 2014); "I have been creative and supported since a kid," for Jason (personal communication, September 20, 2014). Artists provided responses to indicate that learning and making art began early and continued into adulthood for different reasons.

All four participants provided evidence (personal communications as dated above) that they learned early on of their colorblindness. Two artists (Jason and Laura) provided responses about having eye tests around age 8 and noted red-green color vision differences. Caesar indicated confusions with purple-blue colors. Greg indicated confusions with purple and blue,

red and green. Participants commented about having support from family members (e.g. mother, father, spouse, siblings) and peers (e.g. friends, classmates, other artists, people at work) who provided feedback, advice, and/or guidance about color confusions and making art.

Strategies and choices for making art.

All four participants provided evidence (personal communications as dated previously) that they use color in making art. Artists commented on their use of paints (e.g. watercolors, oils, acrylics) and how they see and choose colors. In addition to paints, they mentioned use of other materials/mediums in their artwork: Jason uses the computer for cartooning; Greg builds furniture; Laura illustrates with black and white drawings; Caesar uses objects (magnets, steel wool, pins) with his paint. A closer look at each artist's experiences (artifacts on the Internet and personal communications) provided further insights.

Laura G. Young.

Laura provided resources she found helpful in developing her understanding of color and mixing, such as Bruce MacAvoy's website (http://www.handprint.com/HP/WCL/water.html) about watercolors, *DanKam* simulation application, and *GIMP* color picker tool (see Appendix for design and technology). Laura posted a blog on Tuesday, April, 22, 2014 entitled, "On Being a Colorblind Artist, Part 4: How I Paint" (http://lauragyoung.blogspot.com) where she shared details about her research and how she developed her own system of colors to use. When asked how someone has positively contributed to her work as an artist, Laura acknowledged the support of her "best friend, fellow adventurer and confident … Chad Young" (personal communication, September 29, 2014). In addition to stories posted on her blog about the challenges of growing up with colorblindness,

Laura's Website (http://www.lauragyoung.com) included information about herself, recent works, sketchbook, portfolio of paintings and drawings, and various ways for contact.

Jason Gautier.

Jason responded about using acrylics and Photoshop. On his website he wrote,

> When I used to buy ready made paint sets of acrylic paints, the names of colours used to throw my work off and with names such as burnt sienna or burnt umber it was no wonder my wife noticed I was shading a portrait of children with green and not the reddish brown I believed I was using. Now I use simply the primary colours and two tones to lighten or darken the colours I need for my piece red, blue, yellow, black and white. When using digital paints I hold my mouse over the swatch colour until the prompt confirms I am using the correct colour. (http://jasongautier.co.uk/paintings/)

When asked how someone has positively contributed to his work as an artist, Jason wrote, "My wife is always supportive and helps when I can't see a color" (personal communication, September 20, 2014). Jason's Website included information about himself, cartoons, paintings, comics, videos, and various ways to contact him.

Caesar D. Azalte, Jr.

Caesar's Website included information about himself, his contemporary fine art, and caricature portraits he has made for Disneyland ®. Caesar provided responses about his "self-driven" nature and personal strategies of making art that "has become more tactile, high saturated in color, monochromatic color, minimalism, conceptual…" (personal communication, October 3, 2014) with rare color mixing and use of paints, inks, and pencils already labeled with color names. He described one art making strategy as follows: "I also place colors that are invisible to me or that blend with other colors and I give them a placement in my pallet and I

memorize their position. Also I make them with tactile quality. I place a tape next to it or on it so that I can feel that it is green or that it is turquoise for example" (personal communication, October 3, 2014). When asked how someone has positively contributed to his work as an artist, Caesar acknowledged the positive people and supportive environment of his job at Disneyland®. Caesar included his email address on his Website contact page for communication (http://www.zhibit.org/caesar_alzate_jr).

Greg Schwab

Greg provided responses about his strategies in making art with acrylic paints. He wrote, "[I] try not to worry with actual colors…paint colorful… Once I got past worrying what people thought of my art, I am free to just paint what I want/like" (personal communication, September 18, 2014). He provided additional comments about how an artist emailed him after viewing his art; he received advice from this other artist about needing to use more colors and color mixing. Greg provided follow up reflections on what other professional artists may consider "accurate coloring [within] standards" and offered this comment about teaching kids: "…do it for the pure love of it…. Teach the young artists to be daring and creative and NOT see limitations or silly rules" (personal communication, September 18, 2014). When asked how someone has positively contributed to his work as an artist, Greg listed "colorful" artists such as Rhea Gary and George Rodrique as influences. Greg's Website (http://www.gregschwabart.com/index.html) included information about himself, a gallery with his art, a page for events, and ways to contact him.

Experiences provided by living artists, whether as self-initiated presentations on the Internet or responses to research questions, ask of viewers to take a leap of faith in processing

and analyzing information. As with all Web-based information, teachers must review content before sharing with their learners.

Findings

My research on colorblindness and art education stemmed from personal inquiry about how to share art with learners who are colorblind. Although my investigations probed the complexities of individual differences, findings led to broad-based approaches with universal appeal. By looking at existing art education strategies and insights from artists' experiences, I found connections between art education and colorblindness. Common between contemporary approaches in art education and artists' experiences were three key findings for teaching, learning, and making art:

(1) the use of technology and text within strategies,

(2) the value of multiple means for learning, and

(3) the importance of having support to make art in different ways.

Using Technology and Text within Strategies for Art

My initial literature review led to further investigations into the benefits of using design and technology for colorblindness. Kraft and Keifer-Boyd (2013) wrote, "Many familiar technologies that are available to those with computers and Internet access enable accessibility to plentiful resources, communication, expression, self-representation, community, and experiences not possible prior to the mid-1990's" (p.33). For example, when I used a simulation app to check color-based materials (see Figure 5), I envisioned possible color confusions for art students who are colorblind and thought about how I could modify my studio learning environment to reduce communication difficulties (Flata & Gutwin, 2012). Furthermore, when I considered the definition of technologies to include "tools, techniques, crafts, systems, and

methods" (NCAS, 2014, *Glossary*) I looked beyond digital tools to consider the use of existing *systems* such as the new National Core Arts Standards of 2014 and the principles of Universal Design for Learning and how I could re-consider curriculum content (e.g. re-defining color by way of virtual culture studies as documented in "This is Not RED and Other Color Truths").

Computer software and tools, and simulation applications for hand-held devices have the potential to assist teachers in assessing their learning environments and making modifications. Assistive technology, such as *ColorDeBlind's* color distinguishing feature, has the potential to allow learners to work independently in schools and other settings. The living proof of artists using technology (e.g. graphic design tools, techniques, and methods) and varied text (e.g. written statements, videos, images in art galleries, social media dialogues) exemplified the need for teachers to provide multiple means for learning and making art.

Providing Multiple Means to Support Learning for All

Investigating color, vision, and art turned up medical sources about artists that were/are colorblind (Cole & Harris, 2009; Hansen, 2013; Marmor & Lanthony, 2009; Pickford, 1964; Raven, Anderson, & Lanthony, 1995). Medical scholars highlighted experiences of male artists and how they made art with limited color palettes or non-color materials. In contrast, by virtual inquiry I gained insights from a diverse collection of living artists, female and male who see colors differently and make art with their color vision abilities. All four participating artists use color in their art/work, and with early knowledge about being colorblind, they found different strategies for making art: Laura paints with a self-developed full color palette; Greg uses paint freely without audience pressure; Jason uses computer tools to support his color selections;

Caesar uses other materials to make colors tactile (see "Make a Difference" on my website https://www.hoyangfineart.com/make-a-difference.html).

Although my initial literature review did not turn up evidence that made specific connections between colorblindness and art education, further investigation of these sources led to the new National Core Arts Standards and Universal Design for Learning, with existing frameworks to apply contemporary approaches to art. With multiple means for gathering facts, performing tasks, and getting engaged (UDL) and applying new vocabulary (NCAS), teachers have potential means to move beyond outdated standards (e.g. North Carolina Essential Standards for Art Education).

For example, by using a simulation app to compare common and color-shifted images (see Figures 3 and 5), I reconsidered the design element of color and began documenting ways to re-define color as art and projects to share with learners (i.e. "This is Not RED and Other Color Truths"). I re-visited thoughts about color mixing and wondered, 'Is color theory universal?' Exemplified by living artists who are colorblind and use color in their art, awareness of color theory, models, and mixing is important for art students who wish to develop individualized color palettes unique to their color perceptions, preferences, and visions for experimentation. Discussed later, I project ways to further study color, vision, and art.

Having Support to Make Art with Different Color Vision Abilities

Participant artists attributed learning to self-guided efforts at finding and trying different strategies for using color to meet their individual preferences and interests in making art; beyond learning and developing technique, these artists credited people who supported their endeavors. Each artist who participated in my research acknowledged individuals who

positively contributed to his/her work as an artist: supportive people included family members, classmates, other artists, and people at work. However, responses provided by participant artists did not include school instruction and teachers as positive contributors to their work as artists.

By learning more about colorblindness and applying awareness, I envisioned strategies that could support all learners. For example, if a teacher does not already have a hand-held device (e.g. iPad ®) for use in the classroom, its value as assistive technology used to download simulation applications could support its need as a digital technology tool in the classroom. Kraft and Keifer-Boyd (2013) emphasized that using technologies to empower students and teachers about differences lead to strategies and choices that support all learners to achieve; they footnoted, "Go2Web20.net is a useful directory of Web tools that offers multimodal approaches to communication for inclusive art classrooms" (p. 34). A quick search of the *Go2Web20* directory (http://go2web20.net) did not turn up options for color simulation applications such as the ones I used; however, other apps and tools exist for color and design uses. Consequently, all students would benefit from the availability of a hand-held device that could support learning in multiple ways.

Sharing Findings with Different Audiences

I wanted to share my research findings in varied formats to reach different audiences/viewers. My "UF Research" webpage (https://www.hoyangfineart.com/uf-research.html) exists as a virtual field of choices from which viewers may click on different links to access awareness in a variety of ways, as they wish. My project consisted of two main parts: "Learn and Share" and "Make a Difference." Additional components included, "Research Paper and Resources" and future work for "Exhibition Summer 2015."

Viewers who click on "Learn and Share" will find a graphically designed book-like slideshow that summarizes my research with images and references for a quick read. In addition, I provided a document entitled "Using Colorblind Awareness" with practical how-to's for teachers to consider. Viewers who click on "Make a Difference" will find narratives about participating artists' experiences linked with their Websites; in addition, I encourage viewers to learn more about other living artists who are colorblind by accessing resources collected on my Scoop.it ® (http://www.scoop.it/t/color-blindness-vision-art) and Pinterest ® (http://www.pinterest.com/gracebam/color-vision-and-art/) sites. Finally, my own thoughts about teaching, learning and making art exist as a visual slideshow that accompanies, "This is Not RED and Other Color Truths" (https://www.hoyangfineart.com/uploads/1/6/5/2/16529980/ho_redfinal.pdf).

Discussion and Conclusion

I merged my interests in science and art to explore connections between colorblindness and art education. Color vision deficiency (CVD) is the medical/scientific term for colorblindness, which differentiates color vision from visual acuity and related definitions of visual impairment. The hidden nuances and complexities of colorblindness make awareness even more relevant when education discourses do not specify colorblindness within its definitions and statistics for visual impairment. The topic of colorblindness spans many disciplines, evident in the different areas of study I referenced.

For examples, scientific and medical perspectives provided understandings about color, colorblindness, and artists' choices in using color (Cole & Harris, 2009; Hansen, 2013; Marmor & Lanthony, 2009; Landa & Fairchild, 2005; Lotto, Clarke, Corney & Purves, 2011; Neitz & Neitz, 2011; Pickford, 1964; Raven, Anderson, & Lanthony, 1995). Several design and

technology resources (see Appendix A) for tools, software, and simulation applications potentiate understandings about color and color vision. Education sources on approaches to art and disabilities led to broad-based systems (e.g. National Core Arts Standards) to support multiple means of learning (e.g. Universal Design for Learning). By investigating online, I found artists who made art in different ways and for different reasons, which emphasized the need to find different approaches to art.

When teachers address individual student differences using systems with universal appeal, all students have the potential to benefit from modifications made in the supportive spirit of providing multiple means of learning (National Center on Universal Design for Learning, n.d.). For example, perhaps when teachers use new technologies (e.g. NCAS as a system) and apply assessments with new vocabularies (e.g. tasks and concepts within Model Cornerstone Assessments) they begin to move beyond traditional objectives (e.g. understanding elements within North Carolina's Essential Standards for Art Education) and open up the possibilities of providing multiple means for learning. And perhaps when teachers support learners in the use of assistive technology (e.g. *ColorDeBlind's* feature to distinguish colors), they begin to support learners in independent work in schools and other settings.

Recommendations

Most important of all my findings, I believe support for learners must include significant interactions among individuals involved. Early communications among teachers, parents, learners, and other school personnel could potentiate shared support and responsibilities to address school logistics (i.e. understanding existing procedures to address special needs, disabilities, and individual education plans) and modifications of learning environments. In summary, I believe teachers have the potential to make positive

contributions to art students who are colorblind by using awareness in the following ways:

- Learn "Quick Facts" about colorblindness.
- Share support and responsibility with all involved by initiating and maintaining communications (refer to "Parent-Learner-Teacher Info Sheet").
- Provide multiple means for learning.
- Expect and allow multiple outcomes from learners.
- Use technologies and varied text to see color and make art in different ways.
- Be positive: support and encourage individual differences.

Projections for the Future

By sharing my research findings and projects on the Internet, I envision next steps. For instance, standards and recommendations for school vision screening are not universal (see Appendix A for eye exams). I envision benefits of merging healthcare and education efforts in providing early color vision screening and testing for students before starting school: if students (and their supportive peeps) learn early on of their colorblindness, perhaps they could benefit earlier from multiple strategies (e.g. using design tools, software, and apps) for learning and making. With early color vision screening and tests to arrive at diagnosis, type and severity of colorblindness, learners and teachers may put to use technologies and text earlier; and with awareness, getting hand-held devices to use and assist could potentiate the possibilities for multiple means of learning for all students, given more opportunities to explore color and design apps (e.g. *Go2Web20*, see Appendix A).

As an artist who uses color and paints, I wonder about the specific strategies for color mixing used by artists who participated in my research. I envision benefits of making art with learners and other artists, comparing how we see color and make art in similar and different ways: through collaborative art projects, perhaps we could share the specifics of strategies and choices in how to make art, with new technologies and varied text.

As a retired physician whose love for science remains strong, I rely on the countless lived experiences of people whose lives have intertwined with mine and continue to affect my life with occasional reminders that interactions between people, regardless of systems —medicine, education, institutions—is the key to making a *positive* difference. I think about conversations and recall one former patient who recently shared memories of how we first met over ten years ago, how I took the time to see her in the hospital on my day off from work. I have an ache in my heart knowing that I no longer practice medicine, and when people ask, "Do you miss being a doctor?" I think about the day-to-day interactions I had with people I cared about and know that's what I miss most. I still have science and medicine as knowledge, and nowadays, I love that my interactions with people stem from my creative and geeky ways of living life.

"This is Not RED and Other Color Truths"

While processing my research, I took personal time to revisit my initial thoughts about color, vision, and art and wondered if what I do will make a difference. I came up with a mixed up A-to-Z lexicon of re-definitions[4] for "color" and recorded thoughts and

[4] My thoughts on definitions and codes stemmed from chapters 2 and 5 of *Engaging Visual Culture* (Keifer-Boyd & Maitland-Gholson, 2007).

ideas for art and projects in, "This is not RED and Other Color Truths." I will continue to explore the idea of finding personal truths in the context of daily systems and hope to better understand how to see color and art beyond what's common.

In partnership with our local arts council, I will share my art and work—creative and geeky, artistic and scientific—with my community in an exhibition scheduled for summer 2015 (https://www.hoyangfineart.com/exhibition-summer-2015.html). Currently untitled and existing as ideas in my mind, I envision my as-it-stands-one-person exhibition evolving to include artwork by students and other artists, and interactions with viewers. Ultimately, I hope the exhibition will initiate conversations and engage viewers to ponder how *artists see the world in different ways*.

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Appendix A – Resources

1. Artists and Art Exhibitions

Aaron Brown (photographer – colorblind artist portrait by John Dunkleman)

http://www.aaronbrownphotos.com/About

Aaron Sutton (Florida – painter, teaches)

http://aaronsutton.com

Caesar D. Alzate, Jr. (California – getting MFA)

http://www.zhibit.org/caesar_alzate_jr

Colorblind as We All Art (art exhibit in Hong Kong)

http://www.color-blindness.com/2014/05/14/colourblind-as-all-we-are/

Colorblind Artists on Deviant Art

http://colorblind-artists.deviantart.com/gallery/

Ethan Diehl (photorealistic imagery – painter)

http://www.ethandiehl.com

Greg Schwab (Louisiana – painter; attorney)

http://www.gregschwabart.com/AboutTheArtist.html

Jamie Hayes (Louisiana – painter, gallery)

http://www.jamiehayes.com/artist/

Jason Gautier (UK/Berlin – painter)

http://jasongautier.co.uk/#

John Byrne (comic book)

http://www.byrnerobotics.com/home.asp

John Dunkleman (New York? - painter)

http://www.colorblindartist.com/#artiststatement

Joshua Reach (Colorblind Designer)

http://jdotreach.blogspot.co.uk/2011/05/colorblind-designer.html

Justin Heller (New York - musician and painter)

http://hellerstudios.blogspot.com/p/colorblindness.html

Justin Robertson (UK - painter)

http://www.robertsonfineart.co.uk/artists/justin-robertson

Kilian Schoenberger (Germany - photographer)

http://www.kilianschoenberger.de

Laura G. Young (Colorado - female illustrator and painter)

http://www.lauragyoung.com

Lin Ji (China – female cartoonist)

http://www.chinadaily.com.cn/life/2014-08/02/content_18235884.htm

Making Colours – National Gallery, London (July-September 2014)

"How the Colour-blind See Art With Different Eyes" by Tim Masters.

http://www.bbc.com/news/entertainment-arts-27884975

Neil Harbisson (cyborg painter)

http://www.huffingtonpost.com/neil-harbisson/hearing-color-cyborg-tedtalk_b_3654445.html

Ray Bonnell (American illustrator)

http://sketchesofalaska.blogspot.com/2012/04/known-and-suspected-colorblind-artists.html

Rick Russell (American painter – colorblind artist portrait by John Dunkleman)

http://cbgstudios.com/artists.htm

Tennessee Loveless (American painter – Disney images)

http://tennesseeloveless.com

Wayne Ashworth (painter)

http://wayneashworthart.com/index.html

Yoav Brill – Ishihara (Israel - animation - English version)

http://vimeo.com/yoavbrill

2. Color and Light

7 Simple Facts for Understanding Color Theory

http://99designs.com/designer-blog/2012/08/29/the-7-step-guide-to-understanding-color-theory/

The Fundamentals of Color: Hue, Saturation, and Lightness

http://www.vanseodesign.com/web-design/hue-saturation-and-lightness/

Color theory: Hue and saturation – by Scott Naismith (YouTube)

https://www.youtube.com/watch?v=2rU2Juual18&app=desktop

Color theory: The truth about the color wheel – by Scott Naismith (YouTube)

https://www.youtube.com/watch?v=jQqxN8LpGzw&app=desktop

Is light a particle or a wave? TED Ed video by Colm Kelleher

http://ed.ted.com/lessons/is-light-a-particle-or-a-wave-colm-kelleher#review

Is Your Red the Same as My Red? (…your mind, your perception…)

https://www.youtube.com/watch?v=evQsOFQju08

How we see color. TED Ed video by Colm Kelleher

http://ed.ted.com/lessons/how-we-see-color-colm-kelleher#review

Munsell Color and Science

http://munsell.com/color-blog/munsell-color-and-science/

No Such Thing as Color – video by Laura Evans about Evans Forde (colorblind musician) http://nosuchthingascolor.com

3. Colorblindness – Information, Organizations, Associations

Achromatopsia and Colorblindness – online reference by Windsor & Windsor.

http://www.lowvision.org/achromatopsia_and_color_blindnes.htm

All About Color Blindness – book by Karen Roe Levine

https://pt-br.facebook.com/AllAboutColorBlindness

American Optometry Association on CVD.

http://www.aoa.org/patients-and-public/eye-and-vision-problems/glossary-of-eye-and-vision-conditions/color-deficiency?sso=y

Color Blindness – Medline Plus.

http://www.nlm.nih.gov/medlineplus/ency/article/001002.htm

Colour Blind Awareness Organisation (UK)

http://www.colourblindawareness.org

Colorblind: A Colorful Guide to Colorblindness - YouTube Info-graphic

https://www.youtube.com/watch?v=8Aaivktz8G0

Color Vision Screening and Tests

CVTME = Color Vision Testing Made Easy *(3 to 6 years old, preschoolers)*

http://colorvisiontesting.com/color5.htm

Farnsworth Munsell 100 Hue Test

http://www.xrite.com/online-color-test-challenge

Good-Lite (online site for vision products such as color vision tests)

https://www.good-lite.com/results.cfm?category=18

Ishihara Test. Many online sites available: for example

http://colorvisiontesting.com/ishihara.htm

How to Prepare for the Ishihara Test/Why the Test is Performed, etc.

http://www.nlm.nih.gov/medlineplus/ency/article/003387.htm

How to… YouTube demo for color vision tests

https://www.youtube.com/watch?v=Qq0qHHLV7ic&app=desktop

Procedures for Testing Color Vision – National Academy Press

http://www.nap.edu/openbook.php?record_id=746&page=81

Color Vision Deficiency – Genetics Home Reference.

http://ghr.nlm.nih.gov/condition/color-vision-deficiency

Eye Chart Exam (Snellen) for visual acuity.

http://www.allaboutvision.com/eye-test/

Eye Exam.

Back-to-school Eye Exam… (recommendation: start at age 4 for color vision screening)

http://www.prnewswire.com/news-releases/back-to-school-eye-exams-can-save-children-from-a-lifetime-of-visual-discomfort-266037301.html?__scoop_post=0f113670-0689-11e4-ba0f-

842b2b775358&__scoop_topic=1535377#__scoop_post=0f113670-0689-11e4-ba0f-842b2b775358&__scoop_topic=1535377

Comprehensive Eye Exam.

http://www.aoa.org/patients-and-public/caring-for-your-vision/comprehensive-eye-and-vision-examination?sso=y

Finding the Origins of Colorblindness

https://www.youtube.com/watch?v=1zw2RE-PavQ

How to teach a colorblind child?

http://www.ehow.com/how_6372992_teach-colorblind-child.html

How to teach art to colorblind students?

http://www.ehow.com/how_6403811_teach-art-colorblind-students.html

Human Vision and Color Perception.

http://micro.magnet.fsu.edu/primer/lightandcolor/humanvisionhome.html

ICD-10 is the 10th revision of the International Statistical Classification of Diseases

and Related Health Problems. Retrieved from

http://www.who.int/classifications/icd/en/, para 1:

The International Classification of Diseases (ICD for short) is the standard

diagnostic tool for epidemiology, health management and clinical purposes…

ICD-10 for codes color vision deficiencies
http://www.icd10data.com/ICD10CM/Codes/H00-H59/H53-H54/H53-/#H53.5

Incidence of Color Blindness

http://www.freemd.com/vision-impairment-color-blind/incidence.htm

Kids Health – What It's Like to be Color Blind (includes audio option of text)

http://kidshealth.org/kid/talk/qa/color_blind.html

Other Considerations

Color lenses? http://www.m.webmd.com/men/features/new-look-for-colorblind

Gene therapy? http://www.neitzvision.com/content/genetherapy.html

Pingalapese Colorblind

http://www.genomenewsnetwork.org/articles/06_00/pingelapese_colorblind.shtml

Poor Color Vision (Mayo Clinic).

http://www.mayoclinic.org/diseases-conditions/poor-color-vision/basics/definition/CON-20022091?p=1

Vision Screening

American Optometry Association – Limitations of vision screening

http://www.aoa.org/patients-and-public/caring-for-your-vision/comprehensive-eye-and-vision-examination/limitations-of-vision-screening-programs?sso=y

Visual acuity. *n.* Sharpness of vision, especially as tested with a Snellen chart. Normal visual acuity based on the Snellen chart is 20/20.

visual acuity. (n.d.). The American Heritage® Stedman's Medical Dictionary. Retrieved July 10, 2014, from Dictionary.com website: http://dictionary.reference.com/browse/visual acuity

What is normal by definition?

normal (adj.)

1. usual; regular; common; typical: the normal way of doing it; the normal level

2. constituting a standard: if we take this as normal

3. psychol

a. being within certain limits of intelligence, educational success or ability, etc.

b. conforming to the conventions of one's group

4. biology, med (of laboratory animals) maintained in a natural state for purposes of comparison with animals treated with drugs, etc. ...

normal. (n.d.). Collins English Dictionary - Complete & Unabridged 10th Edition. Retrieved July 10, 2014, from Dictionary.com website: http://dictionary.reference.com/browse/normal

4. Design and Technology

a) Applications and software.

Chromatic Vision Simulator – by Kazunori Asada

http://asada.tukusi.ne.jp/cvsimulator/e/

Colorblinds (computer tools) http://www.colorblinds.org

ColorDeBlind (iPhone app)

https://itunes.apple.com/us/app/colordeblind-how-color-blind/id513529073?mt=8

Colorblind Vision (iPhone app)

https://itunes.apple.com/us/app/colorblind-vision/id401516863?mt=8

DanKam (app) http://dankaminsky.com/2010/12/15/dankam/

Go2Web *http://go2web20.net/app/?a=kuler (directory of Web tools)*

Sound Cloud – audio recorded bit on Color Blind Students

https://soundcloud.com/teachingblindstudents/color-blind-students

Visolve – assistive software for people with colorblindness.

http://www.ryobi-sol.co.jp/visolve/en/

Vischeck – software to show how color deficiency may appear.

http://www.vischeck.com/vischeck/

b) Design.

99 Designs – online marketplace for graphic design.

"Why all designers should understand colorblindness" – by Alex Bigman.

http://99designs.com/designer-blog/2013/04/17/designers-need-to-understand-color-blindness/

Color Design for the Color Vision Impaired

http://colororacle.org/resources/2007_JennyKelso_ColorDesign_hires.pdf

Color Universal Design (CUD)

http://jfly.iam.u-tokyo.ac.jp/color/

Designing for Colorblindness.

http://webaim.org/articles/visual/colorblind#designing

Effective Color Contrast.

http://www.lighthouse.org/accessibility/design/accessible-print-design/effective-color-contrast

Websites for the Colorblind & Color Charts

http://www.toledo-bend.com/colorblind/CBwebsites.asp

5. Special Needs, Disabilities, and Education

National Center on Universal Design for Learning.

http://www.udlcenter.org/aboutudl

Visual impairment in children. (CPIR)

http://www.parentcenterhub.org/repository/visualimpairment/#kids

IDEA Section 504. – excerpt retrieved from

http://www.ncld.org/disability-advocacy/learn-ld-laws/adaaa-section-504/section-504-rehabilitation-act-1973

Section 504 of the Rehabilitation Act of 1973 is a civil rights law that prohibits discrimination on the basis of disability in programs and activities, public or private, that receive federal financial assistance. This law conforms to the definition of disability under the Americans with Disabilities Act Amendments Act (ADAAA). Section 504 does not provide funding for special education or related services, but it does permit the federal government to take funding away from programs that do not comply with the law.

…law defines a person as disabled if he or she:

- has a physical or mental impairment which substantially limits one or more major life activities,
- has a record of such an impairment, or
- is regarded as having such an impairment. 28 CFR Sec.36.104

Appendix B

Research Participation Documents

UF | UNIVERSITY of FLORIDA

The College of the Arts
School of Art and Art History

PO Box 115801
Gainesville, Florida 32611-5801
352-392-9977
352-392-8453 Fax

September 17, 2014

Dear Artist,

I am a graduate student enrolled with the University of Florida's Master in Art Education online program. I'm researching colorblindness as it relates to art education and found your web-based information as an artist who is colorblind.

I currently teach art in the community for learners of all ages and hope that my research will provide additional knowledge for teaching, learning, and making art with colorblind awareness.

If you're interested in participating in my research, I have attached (1) Informed Consent Form and a brief (2) Questionnaire for you to consider. Please feel free to contact me with questions and receive answers before signing the consent form for voluntary participation.

If you choose to participate, please provide responses for the questionnaire as you wish, then save the document as a PDF. As my research is time sensitive, I kindly ask that you email your saved PDF to me (gwho2012@ufl.edu) within one week.

Thank you for choosing to participate.

Sincerely,

Grace W. Ho
Email: gwho2012@ufl.edu
Mobile: (910) 990-1280
UF Graduate work: http://becauseartmatters.weebly.com

UF UNIVERSITY of FLORIDA

The College of the Arts
School of Art and Art History

PO Box 115801
Gainesville, Florida 32611-5801
352-392-9977
352-392-8453 Fax

Informed Consent

Study Title: Color, Vision, and Art: Teaching, Learning, and Making Art with Colorblind Awareness

Purpose of the study
The purpose of this research is to study colorblindness as it relates to teaching, learning, and making art. Please read this consent form carefully before you decide to participate.

What you will be asked to do in the study
If you agree to be a part of the study, you will be asked to answer questions about teaching, learning, and/or making art as they relate to colorblindness. Audio and video recording will not be used.

How much of your time will be required
40 minutes. Please complete the questionnaire within one (1) week after receiving.

Risks and Benefits
The benefits of the study will add knowledge to art education for teachers, learners, artists, and the public at large. You may feel uncomfortable providing information and you may decline to provide responses at any time. If you decide to participate, you may change your mind and withdraw from the study at any time, for any reason.

Compensation
If you agree to participate, you will not be paid or compensated by any means.

Confidentiality
Your identity will be kept confidential to the extent provided by law. All your responses (choose A or B):

___ A. will remain anonymous.
___ B. may be used with references to select items available on the Internet through open access. If you choose B, select items as they relate to your

i. URL and web-based links via open access.
ii. name as noted on the Internet via open access.
iii. art images on the Internet via open access.
iv. statements on the Internet via open access.
v. Other:_____.

Voluntary Participation
Participation in this study is completely voluntary.
Right to withdraw from the study
You have the right to withdraw from the study at any time without consequence.

Who to contact if you have questions about the study
Primary investigator: Grace W. Ho gwho2012@ufl.edu (UF Graduate Student)
Research committee chair: Dr. Michelle Tillander. mtilland@ufl.edu (UF Professor)
Who to contact about your rights as a research participant
IRB02 Gainsville Campus - Ira S. Fischler, PhD, Chair

Voice: (352) 392-0433 Fax:(352) 392-9234 Email: irb2@ufl.edu Web: /irb02.html

I have read the information above, received answers to questions as I wish, and I agree to voluntarily participate in the study.
Check here:____ if you would like a copy of the research when completed (please provide an email address for me to send you a copy).

Print name: _____
Email: _____Date: _____

The Foundation for the Gator Nation
An Equal Opportunity Institution

UF UNIVERSITY of FLORIDA

The College of the Arts
School of Art and Art History

PO Box 115801
Gainesville, Florida 32611-5801
352-392-9977
352-392-8453 Fax

Questionnaire for Participants

Study Title: Color, Vision, and Art: Teaching, Learning, and Making Art with Colorblind Awareness

- As you wish, please provide responses to the following items as they relate to you and your work as an artist, teacher, and/or learner of art.
- Your responses may be as brief or extended, as you wish. Feel free to attach additional pages as needed.

(1) Background information.
As you wish, please provide…

- Name:
- Age:
- Where do you work:
- How does art fit in your life:
  - How did you learn to make art?
  - Why do you make art?
  - Do you make art for a living?
  - Do you teach art to others?

(2) Memories of making art and colorblindness.
As you wish, please consider the following questions in describing past events listed below:

  - How old were you? (e.g. 7 years old, in kindergarten, etc.)
  - What was the setting? (e.g. school, home, friend's house, etc.)
  - Who was with you, if not by yourself? (e.g. teacher, parent, friend, etc.)
  - What were you doing?
  - How does this memory play a part in your journey to becoming an artist/teacher/learner of art?
- An early memory of trying and/or learning to make art.
- When you first realized (learned, were told by someone) that you see colors differently, that you have color vision deficiency, or that you are colorblind.

(3) Strategies and choices in making and seeing art.
As you wish, please describe…

- How you create a typical work of art…perhaps choose to describe a recent piece that you made.
  - What mediums and supplies do you use?
  - What techniques and skills do you use?
  - What strategies and tools have you found to be supportive and useful as an artist who is colorblind?
  - How have you met and learned from challenges as an artist who is colorblind?
- How you view (look at, think about) your art.
  - What/who inspires you to create?
  - What motivates you to create as a professional artist?
- How someone has contributed positively to who you are as a working artist.

(4) Additional Comments and Tips for teaching, learning, and/or making art with colorblind awareness. As you wish, please provide any additional comments and/or suggestions (i.e. tips) for art teachers and students who see colors and art in different ways.

List of Figures with Captions

Author Biography

I work in creative and geeky ways. A blend of art and science contributes to how I think, see, and make sense of life. In 1990, I graduated from Tufts University (Medford, MA) with a Bachelor of Science in Chemistry and Art History, alongside pre-medical studies. I completed my medical degree in 1995 at New York Medical College (Valhalla, NY) and continued my training in Family Medicine at Beverly Hospital in Massachusetts. Along the way, I met the love of my life, Ken Yang and together we have four amazing kids. In 2003 I retired my white coat to spend more time with my family. As my kids grow and slowly age out of needing a chauffeur (one of many jobs I have), I continue to find more pockets of time to revisit my love for art.

I officially began my art career in 2010 when I registered Ho Yang Fine Art (HYFA) as my business. I am a free-lance artist who enjoys drawing, painting, and creating works in mixed media. I teach semi-private art lessons for learners in kindergarten through grade 12. I also share art experiences with my community at our local arts center. My students and their bright ideas keep me on my toes, staying creative and inquisitive about art and life. As I continue to learn and make art, I rely on lived experiences and admit to having had 12 jobs before practicing medicine and making art my career. Today, I love what I do: it's a job filled with multiple tasks and making connections with people I care about. And for students finding your way, dig deep and look beyond quick how-to answers for those probing questions: find meaning in the day-to-day experiences of living life.