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Addressing the Needs of Students With Color Vision Deficiencies in the Elementary School Library

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ADDRESSING THE NEEDS OF STUDENTS WITH COLOR VISION DEFICIENCIES IN THE ELEMENTARY SCHOOL LIBRARY

by

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ABSTRACT

ADDRESSING THE NEEDS OF STUDENTS WITH COLOR VISION DEFICIENCIES IN THE ELEMENTARY SCHOOL LIBRARY

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Color vision deficiencies affect approximately eight percent of the male population (Birch & Chisholm, 2008; Cole, 2007; Jenny & Kelso, 2007; Neitz & Neitz, 2000), yet the condition is often overlooked in the educational setting despite the pervasiveness of color in the school (Suero et al., 2004). The purpose of this study was to explore how elementary school librarians provide instruction and prepare the library environment to meet the needs of students with color vision deficiencies.

This mixed methods study consisted of two components. The first component was a questionnaire administered to elementary school librarians throughout Virginia to gather data related to their knowledge of and attitudes toward students with color vision deficiencies. The second component of the study was a case study of eight elementary school librarians in one school division within Virginia. The case study participants were given the same questionnaire as the state group to assess their knowledge of and attitudes toward students with color vision deficiencies. Then they participated in observations, interviews, and a color vision deficiencies awareness training designed to inform school librarians about issues related to color vision deficiencies. The training was followed by a series of journal prompts through a blog and additional observations to gather information about changes in behaviors. After the training, a post-test was administered

to the case study participants to gather data about changes in knowledge, attitudes, and behaviors.

Findings indicate that elementary school librarians did not feel knowledgeable about color vision deficiencies but were interested in knowing more and expressed a desire to make changes based on participating in the questionnaire alone. The case study participants' increase in knowledge from pretest to post-test was statistically significant. While the change in attitude on the questionnaire was not found to be statistically significant for the case study group, there were noticeable changes in beliefs and desires to change behaviors as evidenced through the qualitative data. The changes in the case study lend support to the need for color vision deficiency awareness training for elementary school educators.

This dissertation is dedicated to my guys:

Richard, my husband and best friend;

Eli, my constant encouragement and support;

Brendan and Jared, whose struggles were my inspiration.

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TABLE OF CONTENTS

Page

Chapter Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

If eight percent of the boys in a class had a physical condition that did not allow those children to access the information being taught, would the educator know about it? Would the educator want to help the students? Would the educator know how to help and make adaptations to the environment and instruction to provide for the needs of the students? Color vision deficiency is sometimes referred to as a "hidden disability" (Tofts, 2007) because this physical condition is not visually apparent and not always identified in affected children. It does not satisfy the definition of a disability according to the guidelines set forth in the Americans with Disabilities Act of 1990 (US Department of Justice, 2012; Patrick, 2000). Regardless, the impact of color vision deficiency on a child in a world full of color could be significant (Tofts, 2007).

Suero hypothesized that much of early childhood education is "based on the use of color as an attribute of objects" (Suero et al., 2004, p. 90). Kindergarten children in Virginia are taught that color is one way to describe an object (Virginia Department of Education [VDOE], 2012a), a concept that is continued in primary grades through third grade. In upper elementary school science classes, children are taught the colors in the visible light spectrum. In Virginia, this is included in the fifth grade Science Standards of Learning (Virginia Department of Education [VDOE], 2010a):

> "The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include:
>
> a) transverse waves;
>
> b) the visible spectrum;

c) opaque, transparent, and translucent;

d) reflection of light from reflective surfaces; and

e) refraction of light through water and prisms." (p. 7)

These concepts are further explained in the *Virginia Science Standards of Learning Curriculum Framework* (Virginia Department of Education [VDOE], 2010b) which outlines the essential knowledge, skills, and processes expected of students in fifth grade. Students should be able to "explain the relationships between wavelength and the color of light. Name the colors of the visible spectrum" (p. 14). Teachers will often teach the mnemonic ROYGBV to help students remember the order of the colors. In the background information provided for teachers in the *Curriculum Framework*, the term "dispersion" is explained as "Dispersion occurs when we see the light separated into a display of colors: ROYGBV" (p. 19). The background information in the framework explains that indigo, between blue and violet, is not often used anymore by scientists (p. 17). Children learn these colors are visible in a rainbow and when light is dispersed by a prism, but children with color vision deficiencies may not see all of the colors. They are then left to memorize the colors in the visible light spectrum with little frame of reference. This conversation between a ten year old boy and his mother illustrates this:

"Mom: What a beautiful rainbow! I know you have learned there are seven colors in a rainbow and you know all about ROYGBIV, but how many do you actually see?"

"Boy: Two. One is yellow...or maybe green. The other is blue. That's it."

"Mom: What do you see above the yellow?"

"Boy: Um...sky?" (K. Collins & J. Collins, personal communication, April 9, 2010)

Figure 1

Photograph of Rainbow Colors

a. Original rainbow photo

b. Adjusted as protanopia

Note: Image corrected using the Color Blindness Simulator www.etre.com

In the conversation recorded above, the mother is the researcher in this study and the boy is one of the researcher's identical twins. Both boys have color vision deficiencies which were discovered early in their preschool years. The researcher knew she was genetically predisposed to have boys with color vision deficiencies because both of her brothers also have the condition.

For the boy in this account and others with similar color vision fields, the mnemonic device ROYGBV becomes the way to memorize something unseen. Similarly, the child must memorize the color wheel when others have the added visual cues to see that red and blue combine to make purple or yellow and blue become green. In science class, what happens when the two colored liquids combine? In geography, where do the colored sections of the map change? In the home, are the bananas a ripe yellow yet or are

they still green? On the sports field, where are the lines on the green field? What colors do the leaves turn in autumn? The list goes on.

An online video titled *No Such Thing as Color-What It's Like to be Color Blind* (Evans, 2011) gives the perspective of a man with color vision deficiencies. The video begins with his experiences in kindergarten when the teachers called in his parents because of the colors he used in his art work and their concern about his emotional state. He talks about how he describes the world, saying,

> People look at something, and one of the first things they think about is what color it is; and I don't ever think about it...If I look at that tree, I think about the shape, the texture of it. If your brain kind of comes up with a list of things that sort of relate to what that is, color is not one of them. I don't even think about what color it is. (3:59-4:28)

To add to the difficulty of the situation, many people with color vision deficiencies do not know they have a deficiency until later in life (Cole, 2007). All of their lives, they have seen the world through their own eyes and have no idea that others see the world differently (Chia, Gazzard, Tong, Zhang, Sim, Fong, & Saw, 2008). One man said he learned that he was color deficient when he was applying to be a police officer and could not pass the color test. He chose a new line of work. (Anonymous, personal communication, January 22, 2013). Neither of the researcher's brothers knew he saw colors differently until he was an adult. One brother learned of his color deficiency when he was learning to be a pilot and could not pass the lantern test. (D. Bame, personal conversation, May 20, 2012). Another man learned he was color deficient as a high school senior when he had a physical to enter the ROTC in college. This man, who is

now an artist, prefers to use premixed paints from the tube instead of mixing his own paint colors since matching a mixed color is nearly impossible for him and would require him to ask someone for help. (A. Martin, personal conversation, March 13, 2013). The irony of the situation is that many jobs that are traditionally of interest to young boys (Todor, 2010), such as jobs with the police, military, and aviation and transportation industries, require that the person pass a color vision test in order to be considered for the job (Cole, 2007).

Background information

Approximately eight percent of the Caucasian male population has some form of color vision deficiency (Birch, & Chisholm, 2008; Cole, 2007; Jenny & Kelso, 2007; Neitz & Neitz, 2000). In a school of just three hundred Caucasian boys, this percentage translates to approximately twenty-four students, or one in twelve, which is enough students to fill a classroom. Statistically speaking, it is likely that each class in the school would have at least one student with color vision deficiencies. The vast majority of these students do see colors, but they view them in ways that are different from those with normal color vision (Birch & Chisholm, 2008).

Color is everywhere in an elementary school, from the bulletin boards to the textbooks to the picture books and instructional materials (Gallo, 1998). Elementary school teachers use color to organize ideas and to give information (Pennsylvania Department of Health [PDOH], 2002). While colorful materials may be more attractive and seem more interesting and educational to most users, there is still eight percent of the population with color vision deficiencies. They do not see colors in the same way and

may not be able to take advantage of the educational use of color like their classmates with normal color vision.

Despite the challenges that may exist for students with color vision deficiencies, this condition is not an identified disability (Patrick, 2000). According to disability statistics provided by the Centers for Disease Control (2012; Pastor, 2008) and the American Academy of Pediatrics (Boyle et al., 2011), the amount of boys with color vision deficiencies relates closely to the amount of boys with Attention Deficit/Hyperactivity Disorder (ADHD). The rate of color vision deficiencies in boys is higher than the rate of many commonly identified disabilities. Tofts (2007) put color vision deficiencies in the category of "hidden disability," a term he also used to refer to dyslexia, a condition which is categorized as a specific learning disability under the US Department of Education's Individuals with Disabilities Act (U. S. Department of Education, 2012).

Departments of education in states throughout the United States vary greatly in their requirements for vision screening in public schools. A search of state Department of Education websites revealed that some states have no mandates on vision screening while others are very specific about the detail they require from vision testing. In the few states where color perception screening is mandated as part of the vision screening, there is further variation about how the information is reported and used by the individual schools. For example, some states provide the screening results to the parent and suggest the parent follow up with an ophthalmologist. Other states give instruction for the school personnel to add the vision screening results to the students' permanent files, and some recommend providing the school nurse, administrator or teacher with the results (Prevent

Blindness America [PBA], 2011.). With such great variation within the country, it is not surprising that little attention has been paid to color vision deficiencies in schools.

There are aspects of color and images which have been highly researched. Information is available that describes the emotional impact of color and how color-coding improves memory (Clariana & Prestara, 2009; Litton, 1979). Researchers have studied how the use of images in textbooks has changed over the years and how color is used in picture books (Torrents, Bofill, and Cardona, 2011) as well as the amount and type of images used in textbooks and other information sources (Lee, 2010). However, the vast majority of the studies found did not include any mention of color vision deficiencies or test for the condition among the study participants. The framework for Universal Design for Learning includes color vision deficiencies in the list of areas for concern (National Center for Universal Design for Learning, 2011), and is thus included as a main topic of discussion in the training session for this study. Despite the relatively current studies related to the general use of color, much of the research found related to the effect of color vision deficiencies on learning is more than twenty years old, written before the increased use of color in instructional materials brought on by technological advances (Cole, 2004; Cole, 2007; Dannenmaier, 1972; Espinda, 1973; Gallo, 1998). This presents a gap in the literature to which this study offers a contribution.

Theoretical and conceptual framework

The theoretical framework embedded within this study was based on Festinger's Theory of Cognitive Dissonance. Festinger theorized that incompatible knowledge, attitudes and behaviors in a person would cause the person to change in order to alleviate the disconnect, or dissonance (Festinger, 1957). This theory applies to this study because,

if educators are exposed to new information about color vision deficiencies and the needs of students with this condition, they hypothetically would experience a dissonance between their behaviors, beliefs and new knowledge. If the participants in this study increased their knowledge about color vision deficiencies and changed their attitudes about the needs of students with color vision deficiencies, they theoretically will want to change their behaviors in order to decrease the dissonance created from this change in attitude and knowledge.

To provide teachers with new information about color deficiencies and the needs of students with this condition, a professional development session was designed for use in this study. The session was designed using the framework of Universal Design for Learning (UDL). This framework focuses on the importance of creating an environment and instruction so that it will be accessible to students with a variety of needs (Center for Applied Special Technology [CAST], 2011). UDL is a method of differentiating instruction by planning for the needs of learners (Stanford & Reeves, 2009). It encourages educators to think about the range of needs possible when designing the learning environment and the instruction in order to be prepared to meet the needs of students with a large variety of needs, not just those of students with identified disabilities.

Stanford and Reeves (2009) contrast UDL with retrofitting, a method of differentiating instruction that takes place once the content is already planned. Retrofitting happens once the educator determines there is a need for changes to meet the needs of a student in the class. Information about the students is gathered then the lesson is differentiated to meet the needs of the students (Stanford & Reeves, 2009).

The UDL framework was an appropriate choice for this study because many children with color vision deficiencies are not aware of their deficiency making it difficult for the educator to make accommodations for unknown conditions (Steward & Cole, 1989). Following the principles of UDL allows an educator to design instruction that will be accessible to students when they enter the instructional space (Passman & Green, 2007). As Creamer (2007) stated,

> It makes more sense to plan and implement a system that is intentionally inclusive of everyone from the beginning than it does to build a system that is modeled after only a few people and then has to be continually reworked to fit the needs of others.

Purpose of the study

The purpose of this mixed methods study was to explore how elementary school librarians provide instruction and prepare the library environment to meet the needs of students with color vision deficiencies. The research was designed to provide data to answer the following questions:

1) What do elementary school librarians know about color vision deficiencies?
2) What attitudes or understandings do elementary school librarians exhibit related to color vision deficiencies?
3) What is the effect of participation in color vision deficiency awareness research on elementary school librarians':
    a. knowledge of color vision deficiencies;
    b. attitudes or understandings of color vision deficiencies and the needs of students with color vision deficiencies;

c. behaviors related to the use of color and the needs of students with color vision deficiencies?

This study consisted of two components. The first component was a questionnaire administered to elementary school librarians throughout Virginia to gather data related to their knowledge of and attitudes related to color vision deficiencies. The second component of the study was a case study of elementary school librarians in one school division within Virginia. The case study participants were given the same questionnaire to assess their knowledge of and attitudes toward students with color vision deficiencies, then participated in observations, interviews, and a training session designed to inform school librarians about issues related to color vision deficiencies. The training was followed by a series of journal prompts through a blog and additional observations to gather information about changes in behaviors. After the treatment, a post-test was administered to the case study participants to gather data about changes in knowledge, attitudes, and behaviors.

This study was significant in providing foundational data about the knowledge and attitudes of elementary school librarians regarding students with color vision deficiencies. It also provided data about the effectiveness of an awareness training session with follow-up site work. The study will affect practice by increasing the awareness of the needs of students with color vision deficiencies and the importance of ensuring all aspects of the school library program are accessible by all students, regardless of their needs. The results of this study may lead to further development of best practices related to training about color vision deficiencies and accommodations for students with color vision deficiencies in elementary school libraries.

Key Terms

Color vision deficiency refers to the inability to discriminate between various colors (Neitz, & Neitz, 2000). According to Suero and her research team, normal color vision is defined as "the ability to match any given color to a mixture of three primary colors in the appropriate proportions" (Suero et al., 2004). Those with color vision deficiencies have difficulty with this matching task, as well as other color discrimination tasks (Neitz & Neitz, 2000). Many with color vision deficiencies compensate by learning to distinguish between the brightness and saturation of the various colors and refer to what they are seeing as "colors" (Atchison, Pedersen, Dain, & Wood, 2003; Jenny & Kelso, 2007; Neitz & Neitz, 2000). Color vision deficiencies are commonly, but incorrectly, referred to as "color-blindness." Specific types of color vision deficiencies will be discussed in chapter two.

Universal Design for Learning (UDL) is defined by the National Center for Universal Design for Learning (2011) as, "A set of principles for curriculum development that give all individuals equal opportunities to learn." UDL provides guidelines for creating instructional materials that are accessible to all learners, no matter what disability or deficiency may be present. In the school library, instructional materials may include picture books, library signage, lesson resources, online information, and other materials used by the teacher as part of library instruction and information retrieval.

Organization of the Study

The study contains five chapters, a bibliography, and appendices. Chapter two consists of a review of the literature which includes background information about color vision deficiencies, then outlines the various types of color vision deficiencies and the

connection between color vision deficiencies and learning. Additional literature discussion includes Universal Design for Learning and disabilities awareness training. Chapter three presents the research design and methodology for the study. It describes the analysis instruments and process used to collect data along with the procedures used to conduct the study. Chapter four gives an analysis of the data and a discussion of the results. Chapter five contains a summary of the findings, conclusions, and suggestions for future research.

CHAPTER 2

REVIEW OF THE LITERATURE

Many different concerns come into play when talking about the use of color in instruction. Overall, the needs of every learner should be taken into account, and all instructional materials and educational settings should be fully accessible by all students (Jenny & Kelso, 2007). Related to color, there is cause for concern when a portion of the student population may perceive the world differently than the rest of the population. This chapter will review the literature that is available related to color vision deficiencies. It will begin by providing an overview of the medical information related to color vision deficiencies, including the causes of color vision deficiencies. It will then give information about the history of color vision deficiencies and discuss the few studies which have been done about color vision deficiencies and education and the emerging field of color vision deficiencies and technology. Further discussion will be related to topics such as Universal Design for Learning and disabilities awareness training.

Color Vision Deficiencies

Color vision deficiency refers to the inability to discriminate between various colors (Neitz, & Neitz, 2000). Most commonly an inherited condition, color vision deficiencies affect approximately eight percent of the male population and approximately one percent of the female population (Jenny & Kelso, 2007). While this may seem like a small percentage, the same amount of students with other disabilities would be cause for concern in the classroom. In fact, the rate of color vision deficiencies is much higher than the rate of most identified disabilities, especially in boys. Table 1 shows the rate of some commonly discussed disabilities as compared to the rate of color vision deficiencies. Data

for Table 1 related to various disabilities came from statistics published by the Centers for Disease Control (2012; Pastor, 2008) and the American Academy of Pediatrics (Boyle et al., 2011).

Table 1

Rate of Common Disabilities and Color Vision Deficiencies

Condition	Rate Overall	Males	Females
Any Developmental Disability (includes autism, ADHD, Visual/Auditory disability, cerebral palsy, learning disability, intellectual disabilities, stuttering/stammering, and other developmental delays)	14%	18%	10%
Color Vision Deficiency	8-10%	8-10%	<1%
ADHD	5-7%	7-10%	3-4%
Learning Disability	5-8%	5-9%	4-5%
Other Developmental Disability	4%	5%	3%
Autism Spectrum Disorder	1% (2007) 2% (2013)	1% (2007) 2-3% (2013)	<1%

The American Academy of Pediatrics published a study to determine the number of children aged three to seventeen with developmental disorders. This study surveyed over 100,000 parents of children in the age range, asking if a doctor had ever diagnosed a developmental disorder, including attention deficit-hyperactivity disorder, autism, visual or auditory disability, cerebral palsy, learning disabilities, intellectual disability, stuttering or stammering, and a general designation for "other developmental delays" (Boyle et al., 2011). The study reported approximately 14% of children, or 10 million, had some type of developmental disability. The rate was higher for boys, at approximately 18%. A new report from the Centers for Disease Control showed an increase in the rate of autism in boys from 2007 to 2012 (Blumberg et al., 2013).

As seen in Table 1, the identified condition with a rate of occurrence closest to that of color vision deficiencies in boys is Attention Deficit/Hyperactivity Disorder (ADHD). Many students with ADHD are eligible to receive special education accommodations under Individuals with Disabilities Education Act (IDEA) or Section 504 of the Vocational Rehabilitation Act (Schnoes et al., 2006). Schnoes describes children with ADHD as having difficulty with tasks that are "crucial to academic success" (p. 483).

It is estimated that 200 million people worldwide have some form of color vision deficiency (Machado et al., 2009). Since so many primary school activities rely on color, it is important for teachers and other school personnel to be aware of the difficulties color may present for some students (Suero et al., 2004). However, many educators are not aware of the condition and how it may affect classroom performance (Gallo, 1998). As more print materials and instructional materials are available in full color, the opportunity for confusion among students with color vision deficiencies has increased (Cole, 2004). The current trend toward the use of computers and technology in the classroom provides another avenue for color confusion (Cole, 2004). Unlike the other disabilities listed in the table, color vision deficiency is not typically considered a disability or eligible for accommodation under IDEA or Section 504 (Color Blind Awareness, 2013; Patrick, 2000).

Medical background

To understand color vision deficiencies, it is necessary to have a basic understanding of how the eye functions. The retina of the eye houses photoreceptors which aid in the ability to see colors. The two types of photoreceptors, rods and cones,

are located in the back of the eye. Rods are responsible for the ability to see in low light, including night vision, while cones are responsible for seeing color (Neitz, & Neitz, 2000). The photoreceptors pass a signal to the brain which then makes sense of the image (Solomon & Lennie, 2007).

Color only exists as part of something. It is never just color; it is always perceived as part of an object (Davidoff, 1991). All objects reflect light in wavelengths of various types and properly functioning cones correctly perceive the wavelengths of the objects in view (Joyce, 2000). Light is reflected off of an object in short, medium, or long wavelengths, the cones perceive the wavelengths, and a message is sent to the brain so color can be determined (Solomon & Lennie, 2007). When cones are not functioning properly or are missing, wavelengths are not perceived as they should be and a person is categorized as color vision deficient. This means that the eye cannot correctly perceive one or more of the three wavelengths (Solomon & Lennie, 2007). Neitz & Neitz (2000) suggest that many color vision deficiencies may be caused by an absence of a particular cone.

A person with normally functioning cones can see all wavelengths of color and is referred to as trichromatic, meaning three colors (Jenny & Kelso, 2007). This condition is only found in humans and primates; most other animals are dichromats (Neitz, Carroll, & Neitz, 2001). The trichromat is able to see the full spectrum of colors. However, it is possible for a trichromat to have cones that all function but are just slightly off from normal, resulting in a slight color vision deficiency (Atchison et al., 2003). This is referred to as anomalous trichromacy and includes protanomaly (red weak) and deutranomaly (green weak). However, research by Neitz and Neitz (2000) suggests that

anomalous trichromacy may actually be caused by the absence of one type of cone with the doubling of another to fill in for the missing type. The table below shows the types of color vision deficiencies.

Table 2

Types of Color Vision Deficiencies

Type	Description	Affects	Example
Trichromacy	All rods and cones work properly		Ability to see full range of colors
Monochromacy	Absence of short (blue), medium (green), and long (red) wavelength cones.	1 in 10,000	Inability to see any colors
Anomalous Trichromacy - One or more color sensitivity is slightly off due to the malfunction of one type of cone. Results in slight color deficiency.			
Protanomaly	Red-weak.	1 out of 100 males; 0.1% of females	Purple appears blue
Deutranomaly	Green-weak.	5 out of 100 males; 0.4% of females	Difficulty telling differences in the red-orange-yellow-green spectrum.
Tritanomaly	Blue-weak.	.0001%	Can be acquired through eye damage.
Dichromacy - One or more cone is absent. Most severe of the red-green defects.			
Protanopia	Red (M) cones absent.	1 out of 100 males; 0.1% of females	Effects perception of blue, violets, and purples because of the dimmed red.
Deuteranopia	Green (L) cones absent.	1 out of 100 males; 0.1% of females	Cannot differentiate between red, orange, yellow, and green.
Tritanopia	Blue (S) cones absent.	.0002%	Can be acquired through eye damage.

A person with protanomaly has a slight difficulty seeing the long wavelength of light and would therefore not be able to easily distinguish between purple and blue, for example (Birch & Chisholm, 2008). Protanomaly affects both the saturation and the brightness of the colors. This condition affects approximately one percent of males and 0.1 percent of females. In a presentation about color vision, Rabin (n.d.) suggested that

protanomaly is caused by the red cones being shifted slightly towards green which diminishes the ability to perceive red. Conversely, deutranomaly results from incorrectly functioning medium (or green) cones and causes the person to be green weak. Again, Rabin suggested that this was due to the green cones being shifted slightly to red and therefore not perceiving the medium wavelength. A person with deutranomaly would have difficulty differentiating colors along the red-orange-yellow-green part of the spectrum. Colors seem skewed towards red with less green apparent although the brightness of the colors is not affected (Birch & Chisholm, 2008). This condition is the most common color vision deficiency, is not typically associated with any other vision impairment, and affects approximately five percent of males and 0.4 percent of females (Neitz, & Neitz, 2000).

There is great range in the severity of color vision deficiencies (Birch & Chisholm, 2008; Neitz, & Neitz, 2000). One type of color vision deficiency is called dichromacy, meaning that only two types of cones function properly with the third being absent or functioning very little (Jenny & Kelso, 2007). This is the most severe of the red-green color deficiencies and affects approximately two percent of males. The two types of dichromacy are deuteranopia and protanopia which affect males equally (Neitz, & Neitz, 2000). In protanopia, the red cones do not work so the brightness of red, orange, and yellow is greatly reduced. A person with protanopia may learn to distinguish colors based on their perceived brightness, so the perception of blues and purples may be reduced in protanopes. Deuteranopia is caused by the absence of green cones. The results are similar to those of protanopia, but the dimming is not as apparent. It is rare for the short wavelength or blue cones to be absent, a condition called tritanopia. When this

occurs, it is typically due to an acquired condition (Neitz, & Neitz, 2000). A clear description of dichromacy comes from Neitz and Neitz (2000):

> Dichromats confuse red with green, and they confuse, with red and green, all colors in the spectrum that fall between them, including yellow, orange, and brown. They see blue and violet as the same color, and blue-green is indistinguishable from white or gray. Magenta and its pastel counterpart also appear white or gray. (p. 695)

The most severe and only truly color blind condition is called monochromacy. This occurs when only one type of cone functions or no cones function, resulting in the absence of any color. Blue cone monochromacy refers to the correct functioning of only the blue cones while rod monochromacy refers to the absence of any functioning cones. Both extremely rare conditions result in the inability to perceive any color. In fact, only approximately one in 10,000 people inherit this form of color vision deficiency (Neitz, & Neitz, 2000); it is more commonly an acquired condition. Neitz and Neitz (2000) describe color blindness:

> It is often said that the term *color blind* is a misnomer. However, it is difficult to find a more appropriate term for individuals who are unable to distinguish all but 2 of the more than 100 hues that are normally seen as different. (p. 695)

In normal color vision, the human eye can detect over one million colors when the full range of the spectrum is taken into account. Dichromats can detect only 10,000 colors and monochromats only 1,000 (Neitz et al., 2001). A dichromat will perceive all wavelengths of a trichromat except what is related to the deficient cone (Valberg, 2005).

On the other hand, some animals such as various types of birds and fish are considered tetrachromatic meaning they have four cone pigments, the additional one being ultraviolet light (Neitz et al., 2001).

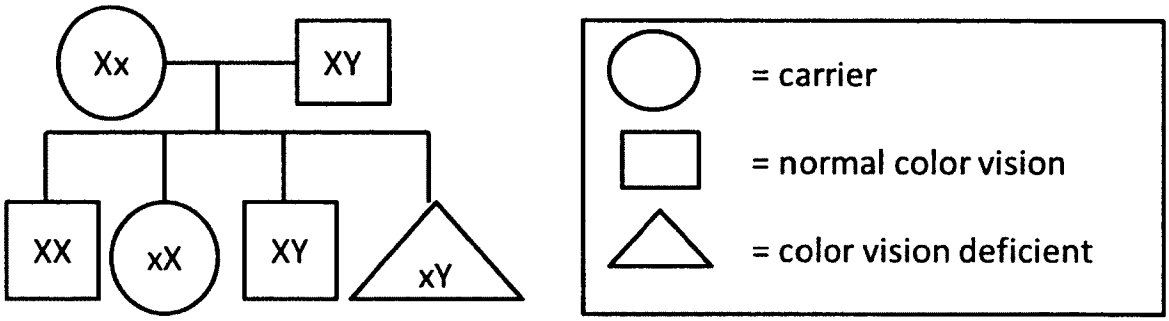
Given the wide range of possible color vision deficiencies, it is difficult to pinpoint the exact type in every affected person. Even if it is known that a student has a color vision deficiency, the exact deficiency may not be known. Or, if there are multiple students within one class who have color vision deficiencies, they may not have trouble with the same colors. Therefore, attention should be given to preparing the learning environment for the general needs of learners with color vision deficiencies by providing color information in other ways as well.

Causes of color vision deficiency

While there are some diseases that can cause acquired color vision deficiencies, most color vision deficiencies, especially in children, are caused by a genetic trait. This trait is linked to an X-chromosome and is a recessive sex-linked trait. Males have a greater chance of having color vision deficiencies because they only have one X chromosome which is passed to the male from the mother. If the inherited chromosome carries the trait, the son would be color vision deficient, and the mother would be a carrier. In the diagrams that follow, the dominant gene is symbolized by an uppercase letter, and the recessive (color vision deficient) gene is indicated by a lowercase letter. Figure 2 shows the pedigree of a mother who is a carrier and a father who is not color vision deficient.

Figure 2

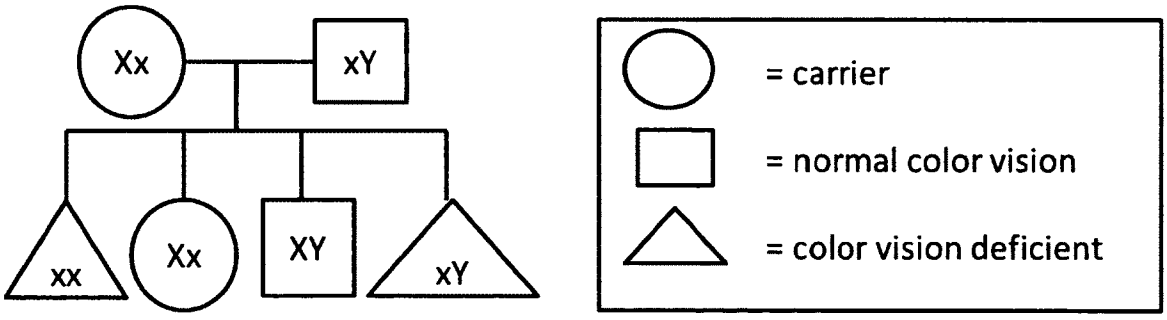
Pedigree - Female Carrier, Male Normal Color Vision



As shown in the figure, females inherit an X chromosome from their father and will be carriers if they inherit the recessive gene from their mother. Because color vision deficiency is a recessive trait, a female will only be color vision deficient if she has inherited an affected gene from both the father and the mother as shown below in Figure 3. This explains the substantially larger amount of males with color vision deficiencies than females.

Figure 3

Pedigree - Female Carrier, Male Color Vision Deficient



There are some medical conditions that can cause color vision deficiencies such as glaucoma, cataracts, diabetes, and head or eye injuries. In these instances, the person

may have had normal color vision until the medical condition caused decreased color vision (Atchison et al., 2003). Many people with acquired color vision deficiencies may not notice the slow deterioration. In addition, color perception may decrease with age. Atchison (2003) estimates that up to an additional 15% of people may acquire color vision deficiencies in their lifetime.

History of color vision deficiency

In 1666, Sir Isaac Newton studied light using prisms and lenses set up in a dark room. Light shining through a hole in a window shutter passed through a prism and revealed the full spectrum of colors. Passing the light back through a lens combined the colors again into white light. In 1704, Newton published the results of his experiments on light and color in a book called *Opticks* (Wasserman, 1978). Although others had set up similar conditions before Newton's experiments, this was the beginning of formal scientific study into the properties of light. Through his research, Newton said that light was made up of a range of colors and each ray reflected off of an object to show color (Valberg, 2005).

The history of color vision deficiencies is documented by many early scholars including Jennings (1905). According to Jennings, the first recorded case of color vision deficiency was reported in 1684 by Turbeville after examining a patient who had come to him with concerns about vision. In 1774, a chemist named Dalton documented his own inability to determine the differences in colors, but he was unaware of the cause (Dalton, 1798). His subsequent research into the condition led to it being referred to as "Daltonism." In 1801, Young gave a speech about how the eye worked saying there were 3 kinds of receptors in the eye, each correlated with one of the primary colors that

Newton had described in his spectrum (red, green, blue). His ideas may have come from the writings of Palmer in the late 1700s (Valberg, 2005).

In 1837, Seebeck began studying color deficient people and created a test that would show color vision deficiencies. The test consisted of thirty colored strips of paper which the subject would have to name and put in order. From his work, he was able to detect two types of color vision deficiencies. In 1850 in Berlin, Helmholtz built on Young's theory of the three categories of colors, developing the Young-Helmholtz Theory, also known as Trichromacy Theory (Purves & Lotto, 2003).

In 1854, Wilson, a chemist from England, was intrigued by the mistakes made by some of his students. He designed a test of colors that consisted of pieces of colored paper that the students would have to name. Any who hesitated were given Seebeck's test for further verification (Valberg, 2005). Wilson was interested in the effect color vision deficiencies had on practical aspects of life such as job related issues. In 1875, an investigation into a railroad accident in Sweden suggested that a railroad employee with color vision deficiencies may have been a factor in the accident (Mollon & Cavonius, 2012). Holmgren, an ophthalmologist who was consulted in the investigation of the accident, worked to develop a quick and inexpensive test that could be given to workers, based on the Young-Helmholtz Theory (Mollon & Cavonius, 2012). His "colour wool" test included a set of differently dyed strings of wool in a range of colors and shades. The person tested had to pick out the same colors from the stings (Keeler, Singh, & Dua, 2009). When given to railroad workers, the railway management was surprised to find workers with color vision deficiencies. This led to a law in Sweden requiring railroad

workers to pass a color vision test before beginning employment (Mollon & Cavonius, 2012).

Hering did not agree with the work of Holmgren and created the Opponent Colors Theory which said there were actually four primary colors (yellow, red, blue, green) and two others (white and black) (Valberg, 2005). Hering hypothesized that people perceive colors through "opponent pairs" which are colors opposite each other on the spectrum. The opponent pairs are black-white, red-green, and yellow-blue (Machado et al., 2009). Hering's theory suggested there is no way to see red in green or blue in yellow because red, green, blue, and yellow are independent colors that do not contain any of the others. Intensity of colors is affected by white and black (Purves & Lotto, 2003).

Today, color perception is still being debated and studied (Lotto & Purves, 2002), some believing the best explanation may be stage-theory, which is combination of trichromacy theory and opponent pairs theory (Machado et al., 2009).

Color vision and daily tasks

In a study conducted by Steward and Cole (1989), 102 people with color vision deficiencies were asked about their experiences with color. Twenty-seven percent stated that they were not previously aware of their color vision deficiencies. Significantly more of those with dichromatic color vision were aware of their condition than anomalous trichromats because of the greater severity of the deficiency. Steward and Cole looked further into how color vision deficiencies affected people in their daily tasks. Approximately 75% of those with color vision deficiencies reported difficulties in daily tasks. Some examples given were determining if meat was cooked thoroughly, fruit was ripe, or skin color was normal. In sports, the condition can cause difficulty in determining

team jersey colors or finding an orange line or ball in the green grass. When driving, people with color vision deficiencies indicated that they used clues such as the position and brightness of the light but still had difficulty with warning lights on the dashboard and brake lights. In an article about his own experiences with color vision deficiencies, Cockburn (2004) detailed his hobby as a sailor and the difficulties he ran into when trying to determine the meaning of signal lights.

Twenty-five percent of the subjects stated that they had been kept from jobs such as military, police, railroad, electronics, and telecommunications due to color vision deficiencies. Cockburn, an optometrist with color vision deficiencies, mentioned a variety of jobs he tried unsuccessfully, such as mixing dyes for a fabric manufacturer (Cockburn, 2004). When he was allowed to join the Royal Australian Navy, he was assigned duties that would not rely on color discrimination. Cole (2007) provided an extensive list of jobs that require some degree of color vision, including jobs that require color matching such as paint or textile work or aesthetic discrimination of colors such as art, fashion, or design jobs. Other careers where color vision is important are in the transportation industry, security and military, and medicine (Cole, 2007).

Participants who were color vision deficient in Steward and Cole's (1989) study reported coping strategies such as decreasing the proximity to the colored object, recognizing the shape of an object, memorizing the order of items, and asking for help. Cole (2007) suggested that optometrists should counsel patients who are newly diagnosed about their career choices and coping strategies. He also reported that many who are newly diagnosed deny the deficiency or any problems associated with it. Color vision deficiencies provide challenges in many aspects of daily life, but those with the condition

would be better equipped to handle the challenges if they were aware of the condition and were given coping strategies (Cole, 2004).

Although Steward and Cole (1989) pointed out that there had been few studies which directly ask color vision deficient people about their experiences, more have been conducted since that time. In 2004, Spalding, a physician with color vision deficiencies, published the findings of an anecdotal study in which he asked other doctors with color vision deficiencies about their experiences. The participants reported trouble identifying blood on dark backgrounds and the presence of rashes or unusual skin coloring that might indicate a particular illness. In the report, he emphasized the need for medical schools to screen students for the condition in order to direct them to specialties that do not require accurate color discrimination or to provide counseling to those who have color vision deficiencies (Spalding, 2004). In a similar article, Cockburn (2004) shared his experiences in a variety of careers and hobbies that were a challenge due to color vision deficiencies.

Neitz & Neitz (2000) stated that those with color vision deficiencies do have trouble with daily tasks such as matching clothes and determining traffic lights. They list some of the "most devastating" problems for people with color vision deficiencies as career choices and early education. They also state that many people with color vision deficiencies learn to distinguish between the brightness and saturation of the various colors and refer to what they are seeing as "colors." Others learn to identify items by other features such as the shape or texture (Cockburn, 2004).

Cole and Lian (2006) studied the ability of people with color vision deficiencies to identify items in nature. They found a statistically significant difference between those

with color vision deficiencies and those with normal vision in three tasks: finding red berries on a bush, tracing the length of a red string on the ground, and differentiating between seasons in landscape scenes depicting summer and autumn. They concluded that color vision deficiencies do impair the ability to identify or see some elements in nature. They link this finding to related tasks such as a police officer identifying an item in a search or a horticulturist identifying plants (Cole & Lian, 2006). This could easily be related to a wide variety of tasks in science classes throughout education.

In an earlier study, Cole (2004) examined research related to color vision deficiencies and wrote about changes in society that have impacted those affected by this condition. Cole discusses two areas of concern: 1) technological changes, such as cheaper printing and more use of color computer monitors and 2) social changes, such as Equal Opportunity Law. According to Cole, various color tasks cause difficulty to various people, depending on the type of deficiency. Like Spalding (2004), Cole recommended ensuring that those with color vision deficiencies are aware of their condition and counseling them appropriately, especially related to careers. Grassivaro Gallo (1998) similarly recommended that teachers be made aware of color vision deficiencies in their students.

Color vision deficiencies can cause difficulties in tasks throughout daily life. Cole (2007) identified three purposes for color: connotative, denotative, and aesthetic. Connotative use of color refers to the message that is conveyed by the color. For example, fruit changes color when it is ripe, and traffic lights tell the driver to stop or go; the color itself gives the message. Denotative refers to colors used to distinguish something from another. For example, the red shirt team is playing the green shirt team.

In this situation, a person with color vision deficiencies might be confused on the game field and give the ball to the wrong team. A denotative use of color uses the color for identification. Aesthetic use of color refers to the look of an object. The color of the flowers in the garden may only be important to a person because of their colorful appearance. However, matching colors that are aesthetically pleasing may be difficult for someone with color vision deficiencies. The purpose of the color is important when determining how color vision deficiencies may impact an aspect of daily life (Cole, 2007).

Color vision and education

Color vision testing is not routinely done in schools in the United States unless it is a part of a state mandate for vision testing (PBA, 2011.). Table 3 shows the variation among state Departments of Education and their requirements for vision screenings.

Table 3

State Vision Screening Requirements and Recommendations

Required screenings		Recommended screenings		
General vision	Color vision	General vision (among those with no requirement)	Color vision	States with no requirement for vision screening
41	7	1	9	9

Among states with required color discrimination screening, there is further variation related to how the results are handled. For example, some states provide the screening results to the parent and suggest the parent follow up with an ophthalmologist. Other states give instruction for the school personnel to add the vision screening results to the

students' permanent files, and some recommend providing the school nurse, administrator or teacher with the results (PBA, 2011.).

Kentucky is one state that requires vision screening of all preschool children prior to entering school. This test includes a color vision screening, but no information was found as to how these data are used in schools (Zaba et al., 2003). Pennsylvania and New York are among other states that include color vision in the mandated vision screening (PDOH, 2002; University of the State of New York [USNY], 2011). Some states such as Oklahoma, Tennessee, and Virginia mandate vision screening but do not include color vision in the mandated screening (Oklahoma State Department of Health [OSDH], 2010; Tennessee Department of Education [TDOE], 2009; Virginia Department of Health [VDOH], 1999). Virginia's document states that testing for color discrimination is recommended due to "educational or vocational implications" (VDOH, p 224). While color vision is not on the mandated screening list for Tennessee and Virginia, both states do recommend color vision screening (TDOE, 2009; VDOH, 1999).

Some states such as Arizona have no mandate for vision screening although the Arizona Department of Health Services [ADHS] (2010) does recommend vision screening for young children and includes color vision screening in its recommendation. In fact, Arizona's Vision Screening Guidelines state, "It is important for parents or guardians, teachers and others to be informed about this condition [color vision deficiencies] as the condition can be reasonably accommodated under Section 504 of the Americans with Disabilities Act" (US Department of Justice, p 14). On the other hand, Joyce (2000) speculated that it would be difficult to find color vision deficiencies as a disability that has a big enough impact on daily life as to be covered under ADA.

In many other countries, most notably the United Kingdom and Australia, color vision is routinely tested in school (Cumberland, Rahi, & Peckham, 2004). These countries test color vision to assist school children in career planning. Gordon (1998) conducted a study to determine if screening should continue given the cost and time it requires. His study supported continued screening to allow teachers to help students develop ways to accommodate and to guide students in an appropriate career path.

Within higher education, screening for color vision deficiencies is inconsistent. Tofts (2007) reported that screening was not conducted in the occupational education program in which he taught although normal color vision is important for most of the jobs for which the students will be trained. Color vision screening is sometimes a requirement for admission to medical school in some countries, but not everywhere, despite the importance of color identification in medical school and medical practice (Spalding, 2004). Knowledge about color vision deficiencies can allow educators to adapt the environment and guide the students' learning (Cole, 2007).

There is very little research into the effect of color vision deficiencies on students in regular educational settings. However, color is a form of communication in early education often seen in tasks such as color coding according to Neitz and Neitz (2000). Young students are expected to learn colors early and those who do not master this may be mistaken as learning disabled, inattentive, or lazy (Suero et al., 2004). Suero's research team studied a group of students with and without color vision deficiencies. While they found little difference in overall learning between the two groups, there was a difference in color-related tasks. There was also a significant difference in how the teachers perceived the students in the two groups. Without knowing who in the class had

color vision deficiencies, the teachers had a lower perception of the learning of the students with color vision deficiencies (Suero et al., 2004). The research team concluded that "the mistakes that Daltonic [term for color vision deficient] children make in tasks involving colours may be misinterpreted by the teacher who is unaware of the disability" (p. 98).

It is interesting to note that much of the research was conducted in the early 1970s when the use of color in instructional materials and media was increasing. Litton (1979) stated in *Color vision deficiency in LD children* that the early 1970s was a time when more textbooks and learning materials were being published in color because color was seen as an effective learning tool. Color coding is viewed as an effective tool for organizing information into patterns that will help the learner make sense of new information (Moore & Dwyer, 1997). However, color coding is of little help to students with color vision deficiencies (PDOH, 2002). Dwyer (1991) stated that the heavy use of color in early learning may not have the desired impact on students with color vision deficiencies at an important stage of educational development. Dannenmaier (1972) also made reference to the increase in the use of color in instructional materials. This topic also was mentioned in relation to maps that were made in the 1970s and 1980s (Olson & Brewer, 1997). Dwyer (1991) states,

> For children with moderate to severe colour vision defects, the impact of colour is reduced both as an attentional and as a learning cue. However, since most colour vision defects in young children go undetected, misperceptions of colour might be misinterpreted

by parents and teachers, thus producing frustration and anxiety (p. 37).

Much of the research that is available related to general education is inconclusive as to the impact of color vision deficiencies on student learning (Wilkinson, 1992). Wilkinson's review of literature related to color vision deficiencies and learning found that some studies show a significant correlation between color vision and learning and some do not. For example, Dannenmaier (1972) was interested in the impact of color vision deficiencies on high school biology students. His study found a significant difference in test scores between color vision deficient and color vision normal students, with color vision deficient students scoring much lower.

Gallo's research team found school achievement in adolescents with color vision deficiencies to be significantly lower than those with normal color vision in all subjects except art and physical education (Gallo et al., 1998). In Knowlton and Woo's (1989) study, subjects with color vision deficiencies performed lower on all tasks than those with normal color vision, especially on tests involving purple ditto copies as opposed to black and white copies. All subjects scored lower on tasks with poor contrast.

Similarly, an article by Jenny and Kelso (2007) discussed the difficulties for people with color vision deficiencies when reading color-coded maps and weather maps, especially in low light conditions. They suggested that color combinations that would not include easily confusable colors would help, such as a color scheme that used green and purple. In *Color design for the color vision impaired* (Jenny & Kelso, 2007), illustrations of working color combinations were given that would provide colors not easily confused, such as purple and green. Knowlton and Woo (1989) stated that it is important for

teachers to be aware of the condition in order to provide a suitable learning environment. This allows teachers to make the necessary accommodations to the environment to meet the needs of the students (ADHS, 2010).

In a large study of school children in Italy, the researchers found that students with color vision deficiencies were significantly less satisfied with their own school achievement as compared to those with normal color vision (Gallo et al., 2003.) Many of those with color vision deficiencies in this study identified school as "made for teaching and not for learning" (p. 218).

A few researchers have found reaction time to be slower in people with color vision deficiencies which could affect performance in the classroom (Olsen & Brewer, 1997). This was mentioned in the map study by Olsen and Brewer (1997) when they found that subjects with color vision deficiencies had a slower reaction time in all tests than those with normal color vision. They stated that one conversation with a color vision deficient subject revealed the subject did not trust what he saw and therefore took a longer time to determine if the colors he was seeing were truly accurate. The authors speculated that inexperience with maps could also cause the slower reaction time in color vision deficient people.

Despite the varied results in the studies, many of the researchers recommend screening for color vision deficiencies. Litton (1979) stated that only one student in his sample of over 100 had information in the school records documenting known color vision deficiencies. The author stated that teachers should keep the individual learners in mind and adapt instruction as needed for each student, including those with color vision deficiencies.

There is debate in the literature about whether color vision deficiencies should be considered a disability. Tofts (2007) referred to color vision deficiency as a "hidden disability" similar to other conditions such as dyslexia. However, there is not a routine screening process in many areas, and Tofts stated that many teachers are not aware of the condition or how it can affect learning or future careers. Tofts' research findings suggested that 60% of the respondents did not consider the needs of students with color vision deficiencies when planning instruction and creating teaching materials (Tofts, 2007). The visual impairment coordinator who was interviewed stated that color vision deficiencies are a minor problem. Litton (1979) recommended all learning disabled students be screened for color vision deficiencies so the teacher is able to adequately meet the needs of every learner.

Similar to the studies related to general education, results of those related to special education are inconclusive. Some studies show a larger amount of students with color vision deficiencies in special education (Dwyer, 1991; Litton, 1979) and other studies show no significant correlation (Salvia & Shugerts, 1970). Espinda (1973) studied students in an "educationally handicapped" class and found a significantly greater incidence of color vision among students in that population as compared to the regular classroom. However, his sample size was very small. A literature review by Schein and Salvia (1969) found that many studies showed a larger rate of color vision deficiencies among students with intellectual disabilities as compared to the regular population. However, they suggested this could be due to a misunderstanding of the test given the disabilities of the students in the sample. Dwyer (1991) found that students with special needs did not have difficulty with the test, yet there was still a higher rate of students with

color vision deficiencies in the special needs classrooms (Dwyer, 1991). Dwyer (1991) asserted that 20% of the sample population in a learning disabled school had some degree of color vision deficiency. He recommended that students with special needs be given more than one type of test to determine color vision deficiency and severity. Dwyer also suggested that, although color is often viewed as an effective learning tool, the use of color in some educational tasks may not be effective with color vision deficient students with learning disabilities (Dwyer, 1991). Salvia and Shugerts (1970) found no difference in color matching, color naming, and word-color association activities between mentally retarded students with and without color vision deficiencies. Litton (1979) studied students in learning disabled classrooms compared to students in regular classrooms and found no significant difference according to his Chi Square statistical analysis. While calculated as not statistically significant, the rate of color vision deficiencies in the learning disabled classroom was 13.5% while the regular classroom rate was only 5.2%. Again, many of the studies found pertaining to color vision deficiencies and special education were performed in the 1950s through 1970s and use outdated terminology and conditions such as special schools for students with disabilities which should be considered when applying the results to today's learners and educational settings.

A large longitudinal study (Cumberland, Rahi, & Peckham, 2004) followed a group of over 12,000 people beginning at the age of seven and continuing until the age of thirty-three, testing them at various ages. The researchers found no significant difference on the two tested areas (achieved education and accidental injuries) between those with normal color vision and those with color vision deficiencies. The article does admit that the use of color in education has increased over the years of the study but downplays this

by stating that most people with color vision deficiencies learn how to compensate and are not at a disadvantage for most educational and occupational needs. However, the commentary does not provide any evidence to support this assertion, and one of the tasks included in the study was described as "copy a design or draw a man." There is no further description of these tasks or if they included color. The study did not state the degree of deficiency in the participants. The conclusion made by Cumberland that the study did not support continuing color vision screening was based on only two factors: educational attainment and accidental injury. As seen throughout this review of the literature, there are many more aspects of color vision deficiencies that should be considered before making such a decision. The ability to differentiate colors has a far more importance within education and in the school setting.

Color vision, technology, and Universal Design for Learning

Adapting technology to the needs of the user with color vision deficiencies is a growing trend in research. The literature related to technology shows the importance of making the information accessible to everyone. The emergence of the idea of Universal Design for Learning assists in this area, putting forth the notion that all information should be designed to be accessible by all people, no matter the condition (Jenny & Kelso, 2007). Therefore, no technology interface should rely only on color, such as color-coding, as a differentiating factor.

Jenny and Kelso made suggestions for universal design in maps and graphics, including: 1) Choose color combinations that do not blend together; 2) Use symbols and other visual clues in place of color-coding; and 3) Label features. They suggest the best option is to change saturation, hue, line width, and add labeling. Moore and Dwyer

(1994) caution that color displays in multimedia can be confusing to those with color vision deficiencies because the large amount of color signals can be misinterpreted if color is the only differentiating feature. Similarly, Cole (2004) discussed the impact of changes in technology, specifically the increase of color computer monitors. He indicated that this change has resulted in new requirements for some jobs as tasks have moved to reliance on a color computer screen instead of a monochrome display.

As technology improves, so does the ability to use technology to make objects easier for color vision deficient people to see. For example, the complex process of map making does not typically allow for a variety of maps to be made for the needs of different users. New technology makes this process easier and less expensive (Olson & Brewer, 1997). Websites, such as Color Oracle and ColorBrewer, are emerging that simulate color vision deficiencies to show web designers what the page would look like to those with color vision deficiencies. Other programs such as Eyepilot and Visolve increase the contrast between confusing colors for color vision deficient users (Jenny, & Kelso, 2007). A website is available that allows the user to upload an image and see what that image may look like to those with color vision deficiencies (Dougherty, 2009). This website and others that perform the same task was used when creating the images used in this study. A program has also been developed that simulates the color ranges seen by those with normal vision, anomalous trichromacy, and dichromacy (Machado et al., 2009) to assist in designing media that will be visible by all users.

Although there is debate about categorizing color vision deficiencies as disabilities, there are some measures in place for ensuring equitable access to instructional materials. One such measure is included in Universal Design for Learning

(UDL), developed by the Center for Applied Special Technology (CAST) in 1984 (CAST, 2012). UDL was designed in the 1980s and 1990s as a way to bring the idea of universal design from architecture into the education world (Spooner, 2007; Zhong, 2012). The principles of UDL include creating a learning environment and content that provides multiple ways of presenting information to students (representation), differentiating student expression of new knowledge (expression), and engaging students in learning (engagement) (CAST, 2012; Spooner, 2007). Adherence to UDL principles allows teachers to develop curricula based on the needs of a wide variety of learners, and accessible to all (Zhong, 2012), and creating a program that "recognizes the unique needs of every learner" (Kortering, McClannon, & Braziel, 2008, p. 352).

The first principle of UDL, "Provide multiple means of representation," begins with a guideline to "provide options for perception" (CAST, 2011). This guideline can be applied to designing instruction for students with color vision deficiencies as it suggests flexibility in the use of color, layout, and contrast on a page. UDL principles also suggest presenting information in more than one way such as using texture along with color or including a pop-up box on a computer program that will give further explanation to the color-coding (CAST, 2011).

Much of the current literature related to Universal Design for Learning described the framework and implementation of UDL; articles providing the steps for ensuring a universally designed lesson or learning space are readily available (Chodock & Dolinger, 2009). Like Chodock and Dolinger, the researcher in this study found little empirical research about the impact of UDL on student achievement. One study of college students in an English class lesson related to Boolean logic, Zhong (2012) applied the concept of

UDL to library instruction. The results of the study indicated that, although few of the students had special learning needs, most of the students felt the UDL-designed lesson was beneficial to their learning.

A few studies have been conducted which analyze the effectiveness of learning UDL on teacher preparation and lesson development. Project ENABLE, a professional development program in New York, included Universal Design for Learning as one component toward their purpose to "create accessible school library programmes and services." (Myhill, Hill, Link, Small, & Bunch, 2012; p. 206.) A study of the program indicated that training in UDL positively impacted the participants' ability to create an accessible library environment. Spooner (2007) developed a study to determine if training in UDL lesson development would positively impact teachers' ability to plan UDL lessons that met the needs of a diverse group of learners. The results showed the short (one hour) training session did significantly increase the creation of UDL lessons. Gavigan and Kurtts (2009) suggested on-going professional development for school librarians to help them effectively use assistive technology and UDL principles in their programs. Principles of UDL can be learned and applied by any educators, not just classroom teachers.

Disabilities awareness training

Although evidence exists that disabilities awareness trainings are beneficial to teachers and other professionals (Hall, 2007; Wilson et al., 2009), there are differing opinions about the best way to conduct disabilities awareness trainings. French (1992) writes about the dangers of using simulation exercises as part of the training sessions, stating that there is little evidence showing the benefit of simulations. On the other hand,

Wilson and his research team (2009) found simulations to be very effective in disabilities awareness training, leading to increased empathy in health practitioners who were involved in the study and a change in the way they related to patients with neurological disabilities. Cole (2007) recommended simulating color vision deficiencies in training so the professionals have a greater appreciation for what someone with color vision deficiencies might see.

In a study designed to determine the effectiveness of disability awareness training, Hall (2007) developed a program for career and technical education teachers which examined how the training affected the knowledge and attitudes of teachers toward students with disabilities. After disability awareness training, the teachers in the study were better able to meet the needs of the learners. The program consisted of four training sessions held over the course of the school year and included lecture, activities, cooperative learning, and classroom follow-up. Using techniques incorporated in the Adult Learning Theory model, the study found an increase in teachers' knowledge about learners' needs, improved attitudes toward students with disabilities, and improved attitudes about teachers' own ability to deal with special needs of students.

Given the extensiveness of color vision deficiencies in males (Cole, 2007; Cumberland et al., 2004; Wilkinson, 1992) and the pervasive use of color within early education classrooms (Suero et al., 2004), little research was found that related the two (Wilkinson, 1992). Additionally, no research was found related to the use of color in school libraries. This study will be an important first step in combining early education, school libraries, and color vision deficiencies by exploring what elementary school librarians know and believe about color vision deficiencies and how they use color in

their library space and instruction. In the next chapter, the researcher describes the methods that were followed in conducting this study.

CHAPTER 3

METHODOLOGY

In this chapter, the researcher describes the methodology for this study which consisted of two elements:

1) Statewide Study

2) Case Study

The purpose of this mixed methods study was to explore how elementary school librarians provide instruction and prepare the library environment to meet the needs of students with color vision deficiencies. This exploratory study consisted of two related studies: a quantitative questionnaire sent to all elementary school librarians in Virginia (referred to as "statewide study") and a case study of eight elementary school librarians from one school division in Virginia who participated in a color vision deficiency awareness training as part of their on-going professional development (referred to as "case study"). The research was designed to provide data to answer the following questions:

1) What do elementary school librarians know about color vision deficiencies?
2) What attitudes or understandings do elementary school librarians exhibit related to color vision deficiencies?
3) What is the effect of participation in color vision deficiency awareness research on elementary school librarians':
    a. knowledge of color vision deficiencies;
    b. attitudes or understandings of color vision deficiencies and the needs of students with color vision deficiencies;

c. behaviors related to the use of color and the needs of students with color vision deficiencies?

For each of the elements of this study, the researcher first describes the research design, followed by the instrumentation, the context and sample, and the procedures followed when carrying out each element of the study. Finally, the researcher describes the procedures for collecting and analyzing data for each element and the limitations of the study.

Statewide Study

Research Design

The statewide study was designed as a one-shot cross-sectional data collection. The purpose of the statewide study was to provide baseline data related to what elementary school librarians in the state know and understand about color vision deficiencies.

Instrumentation

The researcher designed a questionnaire to gather information about the knowledge and attitudes or understandings of librarians in the state related to color vision deficiencies. The questionnaire (Appendix A) included 56 items related to knowledge of and attitudes or understandings about color vision deficiencies. The items for the questionnaire were designed using a table of specifications (Table 4) to ensure the desired topics and constructs are measured adequately and to help establish content validity for the measure (Wright, 2008).

Table 4

Questionnaire Table of Specifications

	Knowledge	Attitude or Understanding	TOTAL
CVD – general information	12	12	24
Specific students – experience	6	6	12
Library design/instruction	10	10	20
TOTAL	28	28	56

The questionnaire used a four-point Likert-type scale which forced the respondents to choose to agree or disagree and quantify their response. Although some of the items could be answered with a yes/no response, the researcher wanted to be able to quantify the level of confidence in the responses through the Likert-type scale. An additional response category was added to the scale for *do not know* to encourage the participants to respond appropriately when they felt they did not know the answer to a question.

A pilot group of twenty-four participants completed the questionnaire, providing feedback to the researcher about the questions. The researcher made minor changes to some of the wording of the questions based on the pilot group's feedback in an effort to make the questions more understandable. Members of the dissertation committee who were experts in the field of school librarianship and research methods also reviewed the questions with the researcher and offered suggestions about whether questions should be retained or changed. No questions were removed from the questionnaire at this point, but open-ended response items were added at various points throughout the questionnaire to solicit comments and a deeper level of data analysis.

The questionnaire was deployed using Survey Monkey Gold to provide a secure online location. A link to the electronic questionnaire was included in an email sent to elementary school librarians within Virginia along with contact information for the researcher, Institutional Review Board approval, and information regarding confidentiality and anonymity of the questionnaire responses. The electronic questionnaire format allowed the researcher to quickly and efficiently collect data from a large amount of people from across the state.

Context and Sample

Over the past few years, graduate professors and graduate students at a university in Virginia developed a database of contact information for elementary school principals and librarians. This database provided the contact information for the statewide study. At the beginning of data collection, the database included 1,232 schools in Virginia which contained at least one grade level of pre-kindergarten through fifth grade. The sample for the statewide study was made up of the voluntary survey respondents from this population of elementary school librarians in Virginia. Given the variety of school configurations throughout the state, "elementary" was operationally defined as any school that included any of the grades pre-kindergarten through fifth grade. This included any middle schools that housed fifth grade. There were no stand-alone preschools in the database. "Librarians" were operationally defined as professionals working in an elementary (as defined above) school library and serving in the role of school librarian, no matter the certification status of the professional.

Schools in Virginia are located in a wide variety of locales, ranging from rural remote to large city (National Center for Education Statistics [NCES], 2010). The

Standards of Quality for Virginia Schools dictates that every public school should staff at least one part-time librarian. In elementary schools, a full time librarian is mandated when enrollment reaches 300 students, and a second full-time librarian is required at the middle and high school levels when student enrollment reaches 1,000 (VDOE, 2012b).

At the time of this study, email addresses were identified for 813 librarians in schools which included elementary grades. Using the email addresses in this database, a link to the questionnaire in Survey Monkey Gold was sent electronically to those 813 librarians. Some emails were returned as undeliverable, at which point the researcher and a graduate student worked to determine the correct email addresses for those that were returned. In all, 786 emails were successfully sent with a requested completion date set as one month from the first email. The voluntary sample for the statewide study consisted of those from the population who chose to respond to the questionnaire.

Procedures

Survey Monkey Gold provides multiple methods for sending a survey. In the researcher's experience with school email systems, emails originating from Survey Monkey and other commercial websites were blocked more frequently than emails originating from .edu accounts, so the researcher sent the link to the Survey Monkey questionnaire using the university email in order to decrease the chances of the email being blocked by school system filters.

The researcher chose the timing of the questionnaire for mid-fall so the librarians had a chance to be settled into the school year. The close date for the questionnaire was set for the day before the Virginia Association of School Librarians annual fall

conference since the researcher was scheduled to present an information session about color vision deficiencies at the conference.

Librarians who served in more than one school only received one questionnaire. In schools with more than one librarian, each received a link to the survey; however, the survey program allowed only one submission from a computer IP address, so each librarian was required to respond on a different machine. This procedure was described in the email to librarians as seen in Appendix B.

In order to protect confidentiality, the demographics portion of the questionnaire did not include any personally identifying information. Survey Monkey software assigned a random participant number to each respondent, and the researcher removed IP addresses that were automatically stored by Survey Monkey before analyzing data to further protect confidentiality.

The first item in the questionnaire provided details about the study and gave the confidentiality and institutional review board information (Appendix C). Participants were asked to agree or not agree to participate in the survey at this point. Those who agreed to the statement moved to the next item. Those who did not agree automatically exited the survey with a screen thanking them for their time. The second item explained the eligibility requirements for the study:

- Currently working as a school librarian in a public school in Virginia;
- In a school which serves at least one of these grade levels: pre-kindergarten through fifth grade.

Those who agreed and were eligible moved to the next item and began the questionnaire. Those who did not agree or meet the criteria automatically exited the questionnaire with a screen thanking them for their time.

The online questionnaire was open for one month, during which time the researcher sent a reminder email to the original list of elementary school librarians, thanking those who had responded and encouraging participation from those who had not yet responded.

Data collection and analysis

After the initial email with the link to the questionnaire and a follow-up email, 269 responses were received in Survey Monkey Gold, a 34% response rate. Of those, 242 agreed and were eligible to participate, making up the sample for the study. The researcher attempted to increase the response rate by sending the reminder email, sending the email from the university email account, and explaining confidentiality measures (Vogt, Gardner, & Haeffele, 2012). While this is a low response rate, the researcher did not extend the date for responses due to the presentation at the conference. Any responses after this presentation would be subject to testing error since the respondents could have attended the conference session or talked to someone who had attended the session. The researcher took the low response rate into account when analyzing the questionnaire data and applying any generalizations to the larger population. Because the responses were kept anonymous and IP addresses were removed, the researcher was not able to determine if there was any difference between those who responded to the initial email and those who responded later.

Quantitative data collected from the statewide questionnaire were analyzed using Survey Monkey data analysis features, Excel spreadsheet software, and SPSS software for descriptive analysis, including mean, standard deviation, and mode. This analysis provided baseline data related to the knowledge and beliefs of elementary school librarians in the statewide study sample.

The researcher combined results from all people who had completed the questionnaire including the statewide sample and the case study participants to increase the participant numbers for determining reliability and validity of the questionnaire. After combining the data into one data set, the researcher ran descriptive statistics and exploratory statistics on the data set.

The researcher created new variables in SPSS to combine the questions related to each construct: knowledge, attitudes/understandings, as seen in Table 5.

Table 5

New Constructs/Scales and Data Collection Methods

Research Question	Construct	Data Collection
What do elementary school librarians know about color vision deficiencies?	Knowledge	questionnaire data
What attitudes or understandings do elementary school librarians exhibit related to color vision deficiencies?	Attitudes/Understandings	questionnaire data

Since the researcher planned to use t-tests for data analysis, statistical tests were run using SPSS to search for outliers and to test the assumptions of normality using the Shapiro-Wilk test, skewness, and kurtosis. Histograms were also examined for a visual analysis of the curve. Cronbach's alpha was calculated to determine the reliability

coefficient of each construct. Levene's test was considered to test the homogeneity of variance when running t-tests for data analysis.

Before analyzing the questionnaire data, each question was examined to determine its relationship to the research questions, as shown in the Appendix D. Five questions related to the librarians' knowledge about specific people with color vision deficiencies were recoded because they did not measure knowledge about the condition of color vision deficiencies; rather, they measured knowledge of people with color vision deficiencies. The researcher determined that this knowledge was something that was not likely to change with participation in color vision deficiency awareness, and were coded for possible analysis as demographic information.

To ensure accurate analysis of the data, some questions were identified for reverse coding based on the wording of the question. The researcher chose to reverse code only questions measuring knowledge since it was not possible to identify an expected response for one's attitudes.

Descriptive data (mean, mode, standard deviation) were collected for individual items on the questionnaire and for the constructs within the one to four scale. Items reported as zero (do not know) were analyzed separately to determine patterns and frequencies of zero responses.

Three open-response items were included within the questionnaire to encourage respondents to give more details about items in the questionnaire. These items provided more information to the researcher and a deeper understanding of the thoughts of the respondents. Responses to these items were analyzed along with the other items in the questionnaire.

Case study

Research Design

The second element of this study was a case study that included eight elementary school librarians from one school division in Virginia. A case study was appropriate for this portion of the study because it allowed for an in-depth examination of a specific group of people within a specific time frame who all took part in a common activity (Creswell, 2009). The quantitative data collection for the case study followed a pre-experimental, one group pretest - post-test design, no control. The dependent variable consisted of data from the questionnaire pre- and post-test, observations, blog posts, and interviews. The independent variable was the training session and study participation. Data were collected through a variety of means, both quantitative (questionnaire) and qualitative (observations, interviews, and blog posts). The goal of the case study was to examine the practices of a small group of elementary school librarians while collecting information that would provide deeper meaning and depth to the quantitative data gathered from the participants in the questionnaire. The case study also allowed the researcher to examine the effect of participating in the study and the color vision deficiency awareness training session on the knowledge, beliefs, and behaviors of elementary school librarians.

The case study followed an emergent design approach, allowing flexibility in data collection so the researcher could gain relevant information during the various site visits. The researcher is a former librarian in the case study school division and worked as a colleague with most of the case study participants. Because of this personal association, the researcher and the case study participants were comfortable talking with each other

during the observations and interviews which allowed for more open conversation. This school division was originally chosen for convenience of access since the researcher lived and worked in the area.

This was a layered case study design in which the individual librarians were studied in their library sites and then all librarians in the school division at all grade levels participated in a common activity, the color vision awareness training, which included weekly blog postings as a training follow-up. Each case study participant was observed again after the training to look for any signs of change in the library space or class instruction.

Cross-case analysis was used to identify patterns within the group of librarians who participated in the case study (Mathison, 2005). Each case study participant completed a pretest and a post-test questionnaire to collect quantitative data related to growth in the participants over the course of the study. Throughout the case study, information was collected from multiple data sources for triangulation of the data to provide a complete picture of what was taking place in each individual case. To ensure accuracy of information and researcher neutrality, the researcher used member checking by reviewing the space observation data with each librarian at the end of the interview. Each librarian was also given the option of reading the interview transcripts to ensure accuracy although none of the participants chose to do so.

Data collected from the larger sample of librarians throughout the state in the statewide study were compared to pre-test results from those in the case study to determine if the case study participants were typical of the larger population. Pretest and post-test data collected from the case study group were analyzed to determine if there was

a significant change in the case study participants after participating in the study. Qualitative data were collected and embedded into the analysis to provide a richer understanding of the results.

Instrumentation

This section covers the instrumentation that was designed by the researcher for use in the case study element of this research. The section gives information about the pre and post observations of the library space and the instructional lesson. Next, the pretest and post-test questionnaires are described followed by a description of the interview. The final instrument that is described in this section is the color vision awareness training that was presented by the researcher to all of the librarians in the school division. A table describing the activities carried out during the case study is provided in Appendix E.

Library space observation. Each case study location received a pre-observation and a post-observation completed by the researcher as an observer. The purpose of the pre-observation was to collect information about the state of the library before the treatment. This observation took place before the librarian completed the pretest questionnaire and before the interview. The researcher observed the environment to collect information about how color is used in the library. Photographs of specific areas in the library were taken for later reference. Samples of materials were collected as research artifacts as appropriate. Observation protocol guided the researcher to ensure that key areas were examined in each library. The specific areas for observation included directional signage, various book sections (picture books, nonfiction, fiction, etc.), story area, classroom/table area, circulation desk, displays and bulletin boards. Within each

area, the researcher took notes and pictures of the use of color in the library space, organizing the notes using the observation checklist (Appendix F).

Instructional lesson observation. The lesson observation was scheduled at a time that allowed observation of a primary grade story time and/or lesson presented by the librarian. Kindergarten was the target grade level for this observation because of the high level of use of color in the grade level and picture books, but first grade was observed when library scheduling made it impossible to observe a kindergarten class. Copies of instructional materials were collected as artifacts or photographs were taken when appropriate. The lesson was audio recorded to gather the information presented in a way that did not interrupt the lesson. This recording allowed the researcher to refer back to specific wording used by the teacher in the lesson. The researcher took field notes during the lesson to capture any reference to or use of color in the lesson. Detailed field notes were written after each observation to provide a basis for later comparison.

Post-observation. The post-observation followed the training session and took place before the post-test. The purpose of the post-observation was to gather data related to how the library environment and lesson presented by the librarian changed since the first observation. Guided by the pre-observation outline and protocol, the researcher observed the library environment noting any changes related to the use of color and taking photographs and collecting artifacts as appropriate.

The post-observation included a story time and/or lesson to a primary grade class in the same manner as the pre-observation, and the researcher again took note of references to color and ways in which the librarian talked about or used color. The post-

observation data were compared to pre-observation data of the same location to provide qualitative evidence of the effectiveness of the treatment on the library program.

Pretest and post-test. The case study group received the pretest and the post-test in a one group pretest-post-test design. The pretest for the case study group was the same questionnaire that was used in the statewide study. The researcher gave the pretest to the case study group in hard copy instead of online. This decision was made so the participants would have the physical copy of the questionnaire when the researcher left the observation. The researcher told each participant that the questionnaire would be collected at the interview establishing a deadline for completion of the questionnaire.

The post-test included all of the items from the pre-test with added open-response items that provided additional qualitative data related to the effectiveness of the training session (Appendix G). Codes were used in place of names to match pre- and post-test responses to specific locations. Participants were reminded of the confidentiality of the information. Open-ended responses were coded for analysis in order to provide a deeper understanding of the effectiveness of the treatment and to give further explanation to the quantitative data.

Interviews. Each participant in the case study was interviewed individually to collect information that is related to his or her specific library program. The interview process allowed the researcher to gain a deeper understanding of the knowledge and attitudes of the case study participants related to color vision deficiencies. Each interview took place following the observation in order to provide an opportunity for the researcher to ask questions specific to the site that may have arisen during the observation. The time and location of the interview were arranged during the observation time and confirmed

before the interview day. All interviews were one-on-one and face-to-face in a location chosen by the participant although the participant's library site was the preferred location so the researcher and participant could reference the library space when necessary.

Each interview was guided by an interview protocol (Appendix H), including informed consent and confidentiality. Each interview was audio recorded after permission from the librarian for later transcription and coding by the researcher and cross-checked by a second researcher for accuracy and to ensure internal consistency. Participants were given the option of reading the interview transcripts to ensure accuracy of information. Interview data were included in the qualitative data collection as one source of information that served to triangulate results and provide a clear picture of what was happening in the sites.

The interviews were semi-structured so all librarians were asked a set group of questions but the natural flow of conversation was not diminished. This also allowed the researcher to ask questions based on specific aspects of the individual observations.

Training session

The main event in the study was a half-day training session provided in the case study school division and presented by the researcher. In this session, the participants learned about color vision deficiencies, the needs of learners with color vision deficiencies, and how to adapt instruction to meet those needs. Time was given to allow the participants to discuss ideas for lessons that follow the recommendations given in the session. The researcher gathered background information for the training session from research and websites from experts in the field of color vision deficiencies. The agenda for the training session is provided in Appendix I.

The training was developed based on the three principles of Universal Design for Learning (UDL): representation, expression, and engagement (CAST, 2012; Spooner, 2007). This framework allowed the librarians to think about how they design their instruction and their space to be flexible enough to meet the needs of learners with color vision deficiencies. Basic background information was provided to participants to ensure they all had a working knowledge of UDL principles. While this was not the major focus of the training session, this emerging area in literature provided a solid framework on which to build this training. As participants developed ideas for lessons and space changes, they were prompted to consider questions that connect to the UDL framework (Browder et al., 2008). The focusing questions were

- Representation - Is there another way the information could be presented?
- Expression - What responses might you expect or accept from students?
- Engagement - How could questions be framed to encourage participation by all students?

The researcher planned a set of blog prompts as a follow-up activity to the training (Appendix J). The prompts were designed to allow the participants of the training to apply the knowledge they had learned and think more about the topic of color vision deficiencies while in their library setting over the next three weeks. The blog prompts asked specific questions to guide the discussion (Hartmann, 2004).

Context and sample

The sample for the case study included eight elementary school librarians from one suburban school division in Virginia. The researcher chose this school division for convenience and accessibility since the researcher was a former school librarian in the

school division and lived in the area at the time of the study. The researcher was granted access to the school libraries and allowed to conduct the study in the division after following appropriate Institutional Review Board policies and school division research study policies.

At the request of the supervisor of libraries in the school division, all school librarians in the school division participated in the half-day professional development as part of the on-going division commitment to professional development in which recertification points can accumulate. To protect confidentiality, the researcher did not release information to the training session participants about which librarians were participating in the case study.

To encourage participation in the entire study, the researcher entered the names of the case study participants into a drawing for a $25 gift card to a local store upon completion of all of the study components then chose the winner at random from all participants who completed all portions of the study. The researcher presented the gift card to the winner after completion of the study.

The case study school division included nine elementary schools, each serving kindergarten through fifth grade, serving a total of over 4,600 students in the 2010-11 school year. Preschool programs served an additional 300 students and were housed within some of the elementary school buildings. However, the preschool students did not regularly use the school library at every location. The schools ranged in size from under 500 students to over 700 students. Most special education students were included in the regular classroom, but there were some special programs in individual elementary schools such as a self-contained program for students with autism. The library staff at

each school library in the division included one full time school librarian and one full time library assistant. The scheduling type varied among schools with some school library programs operating under a fixed schedule of classes and others having some flexible scheduling time. One elementary school ran the International Baccalaureate - Primary Years Program. The librarians had a wide range of years of experience and years with the school system. At the time of this study, one elementary school librarian at a ninth elementary school was out of school for an extended period of time, so it was not possible to include that school in the case study since the position was filled with a long-term substitute instead of the permanent employee of the school division. Due to the nature of the librarian's absence and unknown return date, the researcher did not include this school in the case study.

As stated in the informed consent agreement, each librarian in the case study was given the choice of participation in each stage of the study. One librarian chose not to participate in the interview or the follow-up observation. This librarian did not have time for the interview on the initially agreed upon day and opted out of the interview on the rescheduled day. When the researcher contacted this librarian to arrange a time for the follow-up observation, the librarian stated that nothing had changed and there was no need to return. She did complete the post-test questionnaire. The other seven librarians participated in all elements of the case study.

Individual case descriptions. In order to maintain confidentiality but still allow the researcher to follow the activities of each individual participant, each case in the study was randomly assigned a number and each school given a pseudonym for the school name. Likewise, the participants were each given the opportunity to choose a

personal pseudonym at the beginning of the interview. Those who did not choose a pseudonym were assigned a name by the researcher. Each individual case is described here, based on the information provided to the researcher in the demographics portion of the pretest and in the interviews. While several of the school buildings house preschool programs that are part of the school division, none of the librarians mentioned preschool on the pretest or during the interviews.

Case #1: "Angela." Angela is the school librarian at "Washington Elementary School." She has been a school librarian for seventeen years and is only endorsed in Virginia to teach Library Media PreK-12. Her school serves kindergarten through grade 5, and her library operates on a fixed schedule. She sees kindergarten through third grade each week and fourth and fifth grades twice a month. Her daily schedule includes a forty minute planning time each day, and she describes her opportunities to collaborate with teachers as "hit or miss whenever you can grab someone."

Case #2: "Naire." Naire is the school librarian at "Jackson Elementary School." She has been in education and a school librarian for over twenty-five years. She holds a master's degree and is endorsed to teach Library Media PreK-12. Her school serves kindergarten through fifth grade, and her library is on a fixed schedule. She sees the upper grades (third through fifth) in the morning and the lower grades in the afternoon every day. In the interview, Naire mentioned she has many duties assigned to her outside of the library. Her only planning time in her schedule occurs when there is a grade level with less than five classes, leaving an open slot in the day. However, Naire stated that the resource teachers fill in for each other when necessary instead of hiring a substitute for an absent resource teacher.

Case #3: "Thelma." Thelma is the school librarian at "Roosevelt Elementary School." She has twenty years of experience in education and has been a school librarian for nineteen years. She is endorsed to teach English and Library Media PreK-12. Her school serves kindergarten through grade 5, and her library operates on a fixed schedule, Monday through Thursday. In the interview, Thelma described "Instruction and Enrichment (IE)" which occurs on Friday. This is a scheduled time of twenty-five to thirty minutes for first through fifth grade when teachers send groups of students to the resource teachers for "special" instruction and/or enrichment. She stated that it is difficult to collaborate with teachers because she is teaching the students during the teachers' planning time, so she often finds out what is happening in the classroom by asking the students.

Case #4: "Emily." Emily is the school librarian at "Coolidge Elementary School." She has been an educator and school librarian for five years. Her endorsement is Library Media PreK-12. Her school serves kindergarten through grade 5, and her library operates on a combined (fixed and flexible) schedule. Emily sees the students for library instruction every other week. One week she will have kindergarten through second grade, and the next week she will have third through fifth grade. Kindergarten and first grade also come in for book circulation every week. Because of the flexibility in the schedule, Emily is able to attend grade level meetings during the teachers' planning time.

Case #5: "Lucy." Lucy is the school librarian at "Franklin Elementary School." She has been an educator for twenty-one years and a school librarian for nineteen years. Her endorsements include: English K-12, Health K-12, Library Media PreK-12, and General Education K-8. Franklin Elementary School serves kindergarten through fifth

grade and the library operates on a combined (fixed and flexible) schedule. Her schedule is fixed for kindergarten through second grade, with each class coming for library instruction for forty-five minutes each week. The third through fifth grade classes attend on a weekly rotational schedule (library, computer, guidance, computer), so she sees each class for instruction once every four weeks. However, these students do come in weekly for book circulation only. In the interview, Lucy stated that she meets and collaborates with the grade level teachers "as often as they'll invite me." She indicated that she used to have more success in collaborating with the teachers, but it has become increasingly difficult to get them to collaborate because of increased demands of the curriculum, testing, and the new state teacher evaluation system.

Case #6: "Lottie." Lottie is the school librarian at "Carter Elementary School." She has been in education for over thirty years and has been a school librarian for more than twenty-five years. She holds a bachelor's degree in education and a master's degree in education and is endorsed for Library Media PreK-12. Carter Elementary School serves kindergarten through grade 5, and Lottie's library operates on a fixed schedule. She sees each class in each grade level for forty-five minutes every week. She takes advantage of time before and after school to meet with teachers and meets during their planning times when possible.

Case #7: "Janice." Janice is the school librarian at "Harrison Elementary School." She has five years of experience in education and as a school librarian. She is endorsed for Library Media PreK-12. Harrison Elementary School serves kindergarten through grade 5, and Janice's library operates on a fixed schedule. In the interview, she described her schedule as fixed with some flexible only because of the size of the school.

Because there are not five classes in each grade level, Janice has some open times in her schedule which allow her to meet with teachers and plan collaborative lessons.

Case #8: "Susan." Susan is the school librarian at "Hayes Elementary School." She has been an educator for sixteen years and a librarian for nine years. She is endorsed in the following areas: Reading Specialist, Gifted, Business Education, and Library Media PreK-12. Hayes Elementary School serves kindergarten through fifth grade and the library operates on a flexible schedule.

Procedures

Before any data collection activities at the case study sites, the researcher visited each school in order to obtain written permission from the school principal and arrange a time with the librarian for the first observations (Appendix K). The researcher sent an email to all of the elementary school librarians inviting them to participate and letting them know that the researcher would be in touch (Appendix L). While not required by the school division since data were not collected from students, the researcher gave each principal the option of sending home a letter to parents of students in the class involved to make them aware that the class was going to be audio recorded and that only teacher comments would be included in the transcripts (Appendix M). An informed consent document was provided to the case study participants outlining the various aspects of the case study and explaining how the researcher maintained data to protect confidentiality (Appendix N). The librarian met face-to-face with each of the librarians to schedule the on-site observations.

Observations - library space and instruction. The researcher served only as an observer and did not participate in activities taking place at the site in order to keep from

adding information or ideas that were not part of the site. When possible, the library space observation took place at a time when students were not in the library and conversation with the librarian (if present) was kept to a minimum in order to keep from adding information to the librarians' knowledge and beliefs about color vision deficiencies. An observation protocol was followed and field notes were taken using the observation checklist. During the pre-observation, the researcher took pictures of various physical spaces in the library and made special note of any use of color in the environment.

During the lesson observation, the researcher remained in the back of the space when possible. As the librarian moved around the space, the researcher followed at a distance to record any conversation while remaining as unobtrusive as possible. Any materials presented during the lesson were recorded or collected for analysis of the artifacts. The researcher took note of the titles of books shared during the instructional time to include in the analysis. The researcher took pictures of books and other artifacts after the lesson ended to keep from distracting the students. To ensure the research remained focused on the librarians and not the students, no data was collected from student comments or actions, and student comments on the audio recordings were not transcribed.

Pretest questionnaire. Some statewide study participants emailed to the researcher to say that taking the study had changed their views of color vision deficiencies. Because of this information and a preliminary scan of comments within the statewide questionnaire, the researcher decided to give the pretest to the case study

participants after the observations were complete. This was done to minimize bias that could have been created by taking the questionnaire before the observations.

The pretest was given at the end of the observation time so instructional time would not be affected by the librarian's completion of the questionnaire. Each librarian was asked to return the completed questionnaire to the researcher at the interview session, establishing a time frame for questionnaire completion and allowing the librarians time to consider their responses.

Interview. Following the observation, the researcher scheduled an individual interview with each librarian at a time convenient for the librarian. The researcher determined that the best time for the interview was after the observations and pretest to allow the librarian to ask questions that may have arisen during the observation and pretest. The researcher took note of topics discussed in the individual interviews for possible inclusion in the training session to make sure all participants heard the same information. Although each participant was given the option of reading the transcripts to ensure accuracy, none of them chose to do so.

Training session. After all observations and interviews were complete, all librarians in the school division took part in a half-day training session presented by the researcher which was designed to increase awareness of color vision deficiencies. The school division supervisor of libraries organized the training session for the afternoon following a morning library meeting. The researcher provided lunch to the training session participants and the school division provided substitute librarians to allow the participants to attend the training.

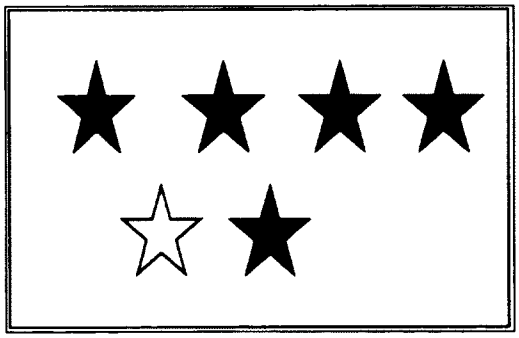
The agenda for the training session is included in Appendix I. The training began with background information about color vision deficiencies based on personal experiences and the research completed by the researcher. Sample scenarios that may occur in a school library and suggestions of how to differentiate instruction to meet the needs of learners with color vision deficiencies were provided using images and lessons from the case study schools.

To give an idea of what the taken images from the libraries might look like to students with color vision deficiencies, the researcher altered the images using an application in the website Vischeck (Dougherty, 2009) and the Color Blind Simulator on etre, a website that assists companies in improving product accessibility and usability (etre, 2013). This website includes an application that converts an image into a simulation of one of three types of color vision deficiencies. Figure 4 shows a group of colored stars that was altered for the training session to show how a range of colors might be seen to someone with color vision deficiencies.

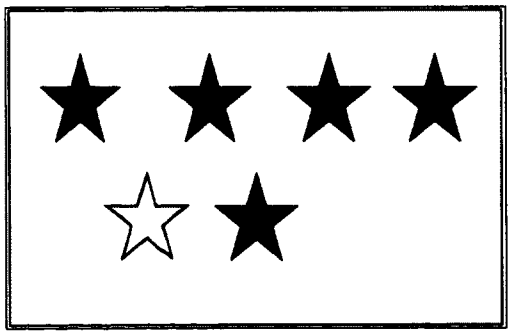
Figure 4

Colored Stars Changed to Simulate Color Vision Deficiencies

a. Original star colors



b. Adjusted for deuteranopia



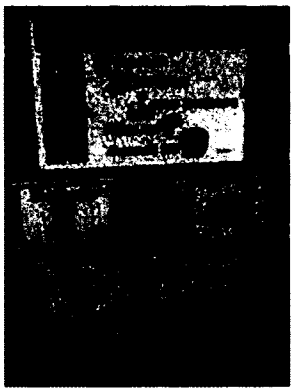
To simulate color vision deficiencies on common items in a school library, the researcher chose a picture of a Dewey Decimal System poster set that was displayed in more than one library. The researcher cropped library images so the school location could not be identified.

Figure 5

Dewey Posters with Normal Color and Adjusted to Simulate Color Vision Deficiencies

a. Normal color

b. Adjusted for deuteranopia



To provide a personal account of living with color vision deficiencies, the video, *No such thing as color* was shown, followed by a brief discussion.

After the video discussion, the researcher led a discussion about the possible impact in school libraries. Participants shared their thoughts as well. The researcher then presented some ideas that the librarians could put into practice to improve accessibility for all students. This included the following ideas.

- Use color – it is a great organizational tool for most people. But provide alternatives.
- High contrast is always best. Consider contrast on signs, handouts, power points, etc.

- Students with color vision deficiencies may not see type on dark page, so use light colored paper and presentation backgrounds.
- When reading a book or sharing stories, explain what is going on in the pictures, or have a student volunteer to explain to the class. Ask questions that will guide the students' understanding of the picture and story.
- Welcome creativity! Don't tell the students their monkey is not realistic if they color it purple.
- If you want students to use specific colors, make it easy for them to get those colors
    - Label the crayons, markers, etc.
    - Encourage students to talk to a friend and ask for help
    - Tell them the colors as you hand them out (scaffolding)

As an example of scaffolding, the researcher shared this personal story about her son's experience in preschool: The teacher was handing out colored hearts and asking each student in the circle to give the name of the color. When she handed the heart to the researcher's son, the teacher prompted him, "You have blue. What color do you have?" He was able to give the correct answer just like the other 3-year olds and participate in the activity.

A lesson example from one of the elementary school libraries was shared with the training session participants. Before using the lesson example, the librarian granted permission to the researcher and the school was not identified in the training session. The lesson was chosen as an example because the book read during the lesson was related to

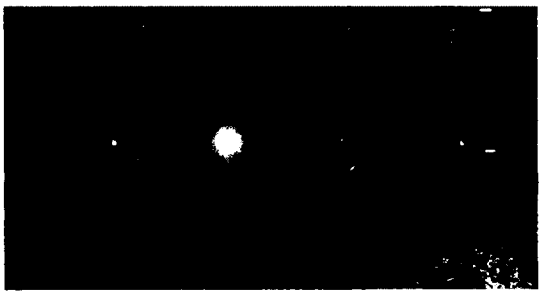
color and the observed librarian provided scaffolding to the students throughout the lesson.

The participants had an opportunity to make decisions about color similar to the experience of a person with color vision deficiencies by playing a game with colored pegs. Participants were given pegs to put in order based on the color adjusted image shown on the screen. The first image showed the actual colors of the pegs. A second image was projected with the adjusted colors in a new order. After the participants attempted to order the pegs, the normal colored image was shown. Figure 6 shows the pegs with normal color and adjusted to simulate color vision deficiency.

Figure 6

Game Pegs in Normal Color and Adjusted to Simulate Color Vision Deficiencies

a. Normal color game pegs



b. Adjusted for deuteranopia

The next element of the training session was related to Universal Design for Learning. Basic information was presented by the researcher, and the group participated in a discussion about the importance of designing the library space and instruction to be accessible to all learners instead of having to retrofit to meet the needs of specific learners. The librarians worked in small groups to brainstorm ideas for implementing the framework of Universal Design for Learning. The brainstorming guide is included in

Appendix O. The researcher provided each participant with a list of resources for further information about color vision deficiencies and about UDL (Appendix P).

At the end of the session, participants were introduced to a blog related to the training session. The purpose of the blog was to provide the participants with an opportunity to extend their learning beyond the training session (Hartmann, 2004) and provide data about the impact of the training on the library programs in the various schools. The researcher showed the steps necessary to log into the blog at the end of the training session and sent a follow-up email with detailed instructions.

The first blog prompt was available to the participants at the end of the training session. In the three weeks following the training, the participants received one blog prompt each week and were asked to respond to the prompts (Appendix J). The blog gave the participants a chance to think about what they learned in the training and write about their experiences and provided the researcher with information related to the training experience in the words of the participants. In order to continue the discussion that began in the training session among all librarians in the school division without singling out those who were participating in the case study, all training session participants were encouraged to participate in the blog. Only responses from case study participants were copied from the blog and included in the qualitative materials for data analysis; 63% of the case study participants posted blog responses. Two participants responded to three of the four prompts. No participants responded to the fourth blog prompt.

Final observation. After the training and time for blog posts, a second observation was scheduled in each of the libraries included in the case study. The purpose of this observation was to discover any changes made by the librarian since the initial

observations. This observation included an observation of the library space and a primary grade lesson. The researcher was specifically looking for ways in which the librarian implemented strategies learned in the training which would indicate a change in behavior. The follow-up library space observation and lesson observation took place in one visit to minimize the distraction to library instruction. Photographs were taken and artifacts collected in a manner similar to the first observation to allow for later analysis and comparison.

During the observation time, the researcher engaged the librarians in an informal discussion about changes in the library program and space and field notes were taken to capture any pertinent comments made by the librarian during this conversation. Audio recordings were typically not used during this talk since the informal conversations were very brief, either before or after the lesson observation. These field notes were included in the qualitative data analysis.

Post-test questionnaire. After completing the final observation, the participants were provided with a link to the post-test/questionnaire in electronic format. This included the same questions as the initial questionnaire but included additional open-ended questions about the training and changes in their library programs and spaces. Since information about color vision deficiencies could have been gathered by the participants during the interviews, observations, training session, blog postings, and post-observations, the post-test was given to the participants at the end of the post-observation. Quantitative data from the two questionnaires were compared to determine any change in the knowledge of and beliefs about color vision deficiencies in the case study

participants. Qualitative data from the open-ended questions were added to the case study data collected through observations, interviews, and blog prompts.

Data Collection and Analysis

After collection of all of the data for the statewide and case studies, the researcher used a t-test to determine any similarity between the statewide study sample and the case study sample. This test was chosen because interval data were included in the study and the t-test is useful for checking the similarity of two normally distributed groups (Pickard, 2013).

Case study data were collected and analyzed first by individual librarians to describe each person, then by case, to describe the group of elementary school librarians in the school division. Quantitative data from the pre- and post-test questionnaires were analyzed using descriptive statistics, including mean, mode, and standard deviation of the scaled responses on the one to four Likert-type scale. As with the statewide study, zero scores were analyzed separately to determine any patterns or frequencies of *do not know* responses. The rate of zero responses was examined in the pretests and post-tests to determine any change.

The researcher used t-tests to determine the effect of the treatment. The independent variable was the treatment (training/participation in the study) and the dependent variable was the librarians' knowledge and beliefs of color vision deficiencies and their behaviors associated with instruction and library space design. Qualitative data were analyzed along with the gain scores to enhance the quantitative findings and aid a deeper understanding of the data.

Qualitative data from the case study included open-ended responses on the questionnaire, observation data, artifacts from the observations, interview transcripts, and blog responses. The data were combined to allow for triangulation of the findings by providing information from a variety of sources. The researcher collected all of the qualitative data for each librarian in the case study, verified the accuracy of the data, and reviewed the information to determine initial categories for coding. Data from one librarian were coded by the researcher using the initial categories. The categories for the data from one librarian were verified by a second researcher to determine inter-rater reliability in the codes.

The researcher worked with a second researcher to verify coding of the qualitative items collected from the observations and interviews. When the two first met, the researcher reviewed the research questions and gave the second researcher a general overview of the study. The two researchers started by coding one lesson observation independently, based on codes the researcher had gleaned from reading through all of the observations. The two researchers met to review their independent codes and discuss any discrepancies. For example, the second coder did not initially code any times when the librarian described a picture unless that description was related specifically to color. Further discussion ensued about the meaning behind each code, and the two researchers decided on three codes for the observations:

- Reference to color;
- Describing a picture or image to the students;
- Questioning the students about a picture or image.

The two researchers independently coded the same observation again with the new clarification, and agreed on 35 of the 39 items coded, resulting in 92% inter-rater reliability on the coded observation.

The researcher followed the same process with the second researcher to determine appropriate coding of the interview. After initial coding and discussion, the researcher determined the following codes for the interviews:

- Knowledge of color vision deficiencies;
- Beliefs about learning, related to color vision deficiencies;
- Behaviors, related to:
    - Differentiation of lessons,
    - Adaptations of the library environment,
    - Gathering information about students.

The two researchers recoded the interview data, and agreed on 29 out of 31 coded items, resulting in 94% inter-rater reliability for the interview.

A similar pattern was followed for the library space observation. As the researchers began to code the data for the first time, both researchers realized the need for further clarification of the meaning of the codes. There was question about whether the color on the sign should be coded or the purpose of the sign itself. For example, would a directional sign be coded as giving information or would the color choice on the sign be coded? After discussion about the intent of the study, the two researchers decided to code the purpose of the color and developed the following codes for the library space observations:

- Color used for decoration and/or design aesthetic;

- Color used for organization or giving information.

Based on these codes, the researchers recoded the space observation independently and agreed on all of the codes, resulting in 100% inter-rater reliability.

Once final categories were established, the remainder of the data were coded by the researcher according to coding protocol. The qualitative data for all case study participants were embedded into the data analysis to enhance and enrich the understanding of the data.

Limitations

Some limitations should be considered related to this research study. First, the case study portion of this study was conducted within one school division in one state. Therefore, the results should not be generalized to the larger population of all elementary school librarians. Second, since there was no control group for post-test data, this study would be considered a pre-experimental design (Creswell, 2009) which leads to some possible alternative explanations for the results such as history or testing confounding variables. It is also possible that the observations and interviews added new information outside of the training session. For this reason, the pretest was conducted before the interviews and the post-test took place after all other activities are completed so all portions of the study (observations, interview, training, and blog prompts) became part of the treatment.

Summary

This mixed methods, exploratory study examined elementary school librarians' behaviors, knowledge, and beliefs about color vision deficiencies. It also examined the effect of a color vision deficiency awareness training on a small group of elementary

school librarians. Quantitative and qualitative data were collected as evidence to support the findings. This study provided background information about what librarians know and believe about color vision deficiencies. It also provided preliminary data to indicate if awareness training and participation in the study had an effect on the behaviors, attitudes, and beliefs of the participants. The results of the study are presented in chapter four.

CHAPTER 4

RESULTS

The purpose of this mixed methods study was to explore how elementary school librarians provide instruction and prepare the library environment to meet the needs of students with color vision deficiencies. This chapter is organized according to the research questions posed in this study:

1) What do elementary school librarians know about color vision deficiencies?
2) What attitudes or understandings do elementary school librarians exhibit related to color vision deficiencies?
3) What is the effect of participation in color vision deficiency awareness research on elementary school librarians':
    a. knowledge of color vision deficiencies;
    b. attitudes or understandings of color vision deficiencies and the needs of students with color vision deficiencies;
    c. behaviors related to the use of color and the needs of students with color vision deficiencies?

Results from the statewide questionnaire and case study pretest are presented to address the first two research questions. Qualitative data from the questionnaires are included in the results. Case study results addressed the last research question and included quantitative and qualitative data collected from pretest and post-test questionnaires, pre- and post observations, interviews, and blog prompt responses.

Preliminary data analysis

Testing assumptions and reliability. Before examining the data as related to the research questions, preliminary data analysis was completed by combining all data from the statewide group and the case study group (pretest) to increase the number of cases available for analysis. The researcher began data analysis of this preliminary group by testing the normality of the two scales, knowledge and attitude, since a t-test would be used to compare the statewide group to the case study group. Cronbach's Alpha was also calculated for all items included in each of the scales to determine reliability of the items in the scales. Results from the tests are shown in Table 6.

Table 6

Test of Normality and Reliability for Preliminary Data

Scales	Questions	Shapiro-Wilk	Skewness	Kurtosis	Cronbach's Alpha
Knowledge	3-1r, 3-2, 3-3, 3-4r, 3-5r, 3-6, 3-7, 3-8r, 3-9, 3-10r, 4-1r, 4-2, 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, 7-7, 8-1, 8-2, 8-3, 11-1r (23 items)	.985	.465	.493	.713
Attitude	4-3, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9, 4-10, 4-11, 5-1, 5-2, 5-3, 7-8, 7-9, 9-1, 9-2, 9-3, 9-4, 9-5, 9-6, 9-7, 9-8, 11-2, 11-3, 11-4, 11-5, 11-6, 11-7 (28 items)	.983	.390	.621	.776

As seen in the table, both scales were within normal limits for skewness and kurtosis (Field, 2009; Vaske, 2008). According to the Shapiro-Wilk test, the two scales were not normally distributed (W=.985, $p < .05$; W=.983, $p < .05$), warranting further investigation. The histograms for the scales showed attributes similar to those of a normal

distribution, including a reasonably central and symmetrical distribution with one high point (McDonald, n.d.). Since data from a number of items were combined to calculate a new combined scale for each of the constructs (knowledge and attitude), the data could be considered interval (Wiersma & Jurs, 2007). The researcher determined the scales met the assumptions for a t-test because interval data were used and the conditions of the histograms were similar to a normal distribution.

Group comparisons. Levene's Test for Equality of Variances was used to determine if equal population variance could be assumed (Vogt, 2007). In the independent samples t-test comparing the means of the statewide group and case study group for the knowledge scale and for the attitude scale, Levene's Test showed the difference between the two groups was not statistically significant. The researcher assumed equal variances between the two groups on both scales. This assumption gave the researcher more confidence that results from the case study group may be similar to the statewide group if the larger group participated in the same color vision deficiency awareness research activities.

Comparing the knowledge scale means of the statewide group (μ=2.81) to the knowledge scale means of the case study group (μ=2.73), no significant difference was found (t (240) = 1.05, $p > .05$). Comparing the attitude scale means of the statewide group (μ=2.68) to the attitude scale means of the case study group (μ=2.73), no significant difference was found (t (235) = -.57, $p > .05$).

Knowledge about color vision deficiencies

The first research question addressed the knowledge held by elementary school librarians about color vision deficiencies. The knowledge items on the questionnaire covered each of these areas, as seen in Table 7:

- general knowledge about color vision deficiencies
- knowledge about students and experiences
- knowledge of library design and instruction.

Table 7

Questionnaire Table of Specifications

	Knowledge	Attitude	TOTAL
CVD – general information	12	12	24
Specific students – experience	6	6	12
Library design/instruction	10	10	20
TOTAL	28	28	56

Twenty-eight items on the questionnaire addressed knowledge, but five of those items were analyzed separately because the items were developed using a categorical (yes/no) scale. These items were more closely related to the participants' experiences with people who have color vision deficiencies; therefore, the items provided information that should not change with increased knowledge. Results from these five items are presented later in this chapter.

For the remaining 23 items related to knowledge on the questionnaire, participants responded on a four point Likert-type scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Each item also included a *do not know* response scored as zero that

allowed participants to give this response instead of guessing. The knowledge items were combined to create a new scale for "knowledge."

The researcher analyzed each knowledge item separately to glean more detailed information about the participants' knowledge of color vision deficiencies. Descriptive statistics, including mean, standard deviation, and mode were calculated for each item, as well as the amount of zero scores for each item. The researcher included zero scores when calculating mode in order to determine which items received the most responses in the *do not know* category. These items were considered for further analysis when comparing the case study pre and post test data. Before the mean and standard deviation were calculated, zero scores were coded as missing so the mean represented the average of the responses on the Likert-type 1-4 scale and did not include the zero scores.

Statewide questionnaire. Results of the statewide group were analyzed first for the knowledge scale. Descriptive statistics were calculated for that scale, resulting in a mean score of 2.82, $sd = 0.218$, $N = 242$. Descriptive statistics for each item in the knowledge scale are included in Table 8.

Table 8

Descriptive Statistics for Knowledge Items - Statewide Questionnaire

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
3-1r	Color vision deficiency means the person sees everything in black and white	241	3.30	0.625	3	19
3-2	There are careers which require normal color vision	241	3.31	0.658	3	11
3-3	Color vision deficiencies are inherited conditions	241	3	0.567	3	82
3-4r	Color vision deficiencies can be corrected with treatment	241	3.09	0.558	3	77
3-5r	All people with color vision deficiencies see colors in the same way	242	3.44	0.558	3	21
3-6	Color vision deficiencies are more prevalent in males than in females	241	3.12	0.652	3	53

Descriptive Statistics for Knowledge Items - Statewide Questionnaire (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	241	2.32	0.654	2	87
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	241	2.17	0.56	2	79
3-9	Background color may make it difficult for some students to read the words on a page	242	3.23	0.631	3	15
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	241	3.26	0.598	3	11
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	237	2.97	0.65	0	125
4-2	Lighting can affect a person's ability to distinguish between colors	237	3.23	0.508	3	14
7-1	I refer to color in pictures when reading books to students	230	2.84	0.59	3	2
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	229	2.96	0.577	3	1
7-3	Book levels are indicated by color-coding in my library	231	2.37	0.919	2	1
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	228	2.54	0.749	3	22
7-5	The library website is visually accessible to all users	231	3.03	0.58	3	52
7-6	I use instructional materials that have colors which are visually accessible to all students	231	2.95	0.479	3	84
7-7	Color is a large component of whole group instruction in my library	230	2.08	0.554	2	3
8-1	I consider the needs of students with color vision deficiencies when designing lessons	228	2.09	0.512	2	19
8-2	I consider the needs of students with color vision deficiencies when decorating the library	226	2.19	0.565	2	17
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	226	2.33	0.679	2	17
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	229	2.64	0.704	0	174

As stated in chapter three, seven of the knowledge items were reverse-coded because those items were written to elicit negative responses from those with knowledge of color vision deficiencies. In Table 8, the seven reverse coded items are identified with

"r" after the item number. Three of these reversed items received some of the highest mean scores, indicating the respondents were familiar with the topics presented in these questions: Item 3-1r ($\mu = 3.30$), "Color vision deficiency means the person sees everything in black and white," and item 3-5r ($\mu = 3.44$), "All people with color vision deficiencies see colors in the same way," item 3-10r ($\mu = 3.26$) "The name of a color (blue, green, etc.) means the same thing to all people."

High mean scores also appeared in item 3-2 ($\mu = 3.31$), "There are careers which require normal color vision," item 3-9 ($\mu = 3.23$), "Background color may make it difficult for some students to read the words on a page," item 4-2 ($\mu = 3.23$), "Lighting can affect a person's ability to distinguish between colors." These high mean scores indicate the participants may have a higher level of knowledge about these topics.

Items with low mean scores were related to the consideration of color vision deficiencies when planning the library program and instruction, items 8-1 ($\mu = 2.09$), 8-2 ($\mu = 2.19$), and 8-3 ($\mu = 2.33$). Item 7-7 "Color is a large component of whole group instruction in my library," also had a low mean ($\mu = 2.08$).

Item 7-3, "Book levels are indicated by color-coding in my library," had a high standard deviation ($sd = 0.919$), indicating a large discrepancy among responses.

Mode was calculated for the knowledge items to determine when the highest response was *do not know*. Item 4-1r ($Mo = 0$, n = 125), "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school" and item 11-1r ($Mo = 0$, $n = 174$), "Color vision deficiency is classified as a disability under special education guidelines," both had a mode of 0, indicating the greatest response on each of those questions was *do not know*. Other items with a high percentage

of respondents choosing *do not know* included item 3-3, item 3-4r, item 3-7, item 3-8, and item 7-6. The researcher noted these items for further analysis when comparing the pre and post test scores in the case study to determine if there was a change in these scores after participation in the case study.

Three open response items on the questionnaire allowed participants to give more detail about their knowledge of color vision deficiencies. Item six asked, "What additional thoughts do you have about color vision deficiencies?" Of the 43 responses, fourteen shared personal experiences with someone who had color vision deficiencies, often a father, husband, brother, or son. Thirteen respondents stated they had no prior knowledge of color vision deficiencies before completing this questionnaire, and nine stated that their participation in the questionnaire changed their understanding of color vision deficiencies.

Item ten, the second open response item in the questionnaire, followed a series of items about how color is used in the library. This question asked, "What additional information would you like to add about the use of color in your library?" Thirty-six participants responded to this question, and 14 of those respondents stated they had no knowledge of color vision deficiencies before participating in this questionnaire. Eight of the respondents stated they would think about their instruction or library program differently after participating in this questionnaire. One participant stated, "I have never considered color-blindness and couldn't understand the correlation with the library until I took this survey."

The questionnaire contained six knowledge items using a categorical scale of Yes or No. The results of these items are listed in Table 9.

Table 9

Knowledge Items with Categorical Values - Statewide Questionnaire

Item #	Item	Number Yes	Percent Yes	Number No	Percent No
12	Have you ever been told by someone in the school that a specific student is color blind?	20	8.7	209	91.3
12-o	If so, what position did that person hold? (teacher, special education teacher, nurse, etc.)		Open response item		
13	Have you ever been told by a parent that a specific student is color blind?	16	7	213	93
14	Have you ever been told by a student that he/she is color blind?	17	7.6	207	92.4
15	Do you know anyone (other than students) with color vision deficiencies?	142	62.6	85	37.4
16	Have you ever suspected that a specific student is color blind?	19	8.3	209	91.7
16-o	If so, what did you do?		Open response item		
18	Have you attended any previous disability training (class, workshop, etc.)?	156	68.1	73	31.9
18-o	Was color vision mentioned?	6		130	

As seen in the table in items 12, 13, and 14, the overwhelming majority of respondents stated they had never been told about a student with color vision deficiencies. A similar percentage of respondents to item 16 stated they never suspected a student of having color vision deficiencies. On the other hand, 62.6% of respondents to item 15 stated they knew someone other than a student with color vision deficiencies. Over half of the respondents to item 18 stated they had attended disability training in the past, but only six indicated remembering the mention of color vision deficiencies in the training.

An open response item was included for further clarification of item 12, "Have you ever been told by someone in the school that a specific student is color blind?" The open response item asked for the position in the school held by the person who gave the information. Seventeen participants responded to the open response question, some listing more than one person who gave the information. Positions which fell into the "other" category included art teacher, gifted resource teacher, and "It has varied over the years." As presented in Table 10, most participants indicated they were told about a student's needs by the teacher. The fewest number reported being told by the school nurse.

Table 10

Position of Person in the School Who Gave Information about a Student with Color Vision Deficiencies

Person Informing	N
Nurse	2
Parent	4
Special Educator	5
Teacher	9
Other	4

In item 16, 19 respondents indicated they had suspected a student had color vision deficiencies, and 17 responded to the related open response item. Of those seventeen respondents, eight indicated they reported the suspicion to someone. Table 11 shows the person to whom the respondents reported their suspicion. Other actions taken included referring the student for testing ($N = 2$) and talking to the student about the concern ($N = 4$).

Table 11

Actions upon Suspicion of Color Vision Deficiency

Reported suspicion to	N
Art teacher	2
Nurse	2
Parent	2
Special Educator	1
Teacher	4

Some respondents gave examples of accommodations made for students with suspected color vision deficiencies. These accommodations included "repeated the color related question," "reworded the directions," and "helped him select colors when coloring, playing board games, worked together when putting together puzzles."

Case study pretest. The knowledge scores for the case study pretest were analyzed in the same manner as in the statewide questionnaire. For the combined knowledge scale, the mean score was 2.73, $sd = .129$, $N = 8$. Descriptive statistics (mean, standard deviation, and mode) were calculated for each item, as well as the number of respondents who chose zero. These data are shown in Table 12.

Table 12

Descriptive Statistics for Case Study Pretest – Knowledge Items

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
3-1r	Color vision deficiency means the person sees everything in black and white	8	3.43	.535	3	1
3-2	There are careers which require normal color vision	8	3.50	.535	3	0
3-3	Color vision deficiencies are inherited conditions	8	3.00	.000	3	3
3-4r	Color vision deficiencies can be corrected with treatment	8	2.67	.577	0	5
3-5r	All people with color vision deficiencies see colors in the same way	7	3.00	.548	3	1

Descriptive Statistics for Case Study Pretest – Knowledge Items (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
3-6	Color vision deficiencies are more prevalent in males than in females	8	3.00	.000	3	0
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	8	2.17	.753	2	2
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	8	2.33	.516	2	2
3-9	Background color may make it difficult for some students to read the words on a page	8	3.14	.378	3	1
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	8	3.13	.641	3	0
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	8	2.33	.577	0	5
4-2	Lighting can affect a person's ability to distinguish between colors	8	3.25	.463	3	0
7-1	I refer to color in pictures when reading books to students	8	2.75	.463	3	0
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	8	2.88	.835	3	0
7-3	Book levels are indicated by color-coding in my library	8	2.63	.518	3	0
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	7	2.00	.577	2	0
7-5	The library website is visually accessible to all users	8	3.00	.000	0, 3	4
7-6	I use instructional materials that have colors which are visually accessible to all students	8	3.00	.000	0	5
7-7	Color is a large component of whole group instruction in my library	8	2.29	.488	2	1
8-1	I consider the needs of students with color vision deficiencies when designing lessons	8	2.13	.354	2	0
8-2	I consider the needs of students with color vision deficiencies when decorating the library	8	2.13	.354	2	0
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	7	2.14	.378	2	0
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	8	2.00	.000	-	7

The items with the highest mean scores in the case study pretest were item 3-1r, "Color vision deficiency means the person sees everything in black and white," item 3-2, "There are careers which require normal color vision," item 3-9, "Background color may make it difficult for some students to read the words on a page," item 3-10, "The name of

a color (blue, green, etc.) means the same thing to all people," and item 4-2, "Lighting can affect a person's ability to distinguish between colors." All of these items received a mean score over 3.00. These high mean scores suggest the participants have a greater knowledge of these areas.

The lowest mean scores for the case study pretest were on item 7-4, "When color-coding, I provide the information in another way as well (shape, design, etc.)," and item 11-1r, "Color vision deficiency is classified as a disability under Special Education guidelines." However, it should be noted that seven of the eight respondents chose zero for their response to 11-1r, so the 2.00 mean score was actually the score for the one person who did not choose *do not know*.

In addition to item 11-1r, four other items had a mode of 0, indicating a high number of *do not know* responses. These items were item 3-4r, 4-1r, 7-5, and 7-6. The mode for item 7-5 tied with 0 and 3, since half of the respondents chose each response. The researcher noted the items with a mode of 0 for specific analysis when comparing these scores to the case study post test scores.

The item with a high standard deviation was item 7-2, "Signage in the library uses high contrast colors (black/white; red/yellow)," indicating a high degree of discrepancy between the responses.

The case study participants completed their pretest in print format instead of using the online survey, but there were very few responses to the open response questions from this group. One person did state "I never really thought about it before," when asked "What additional thought do you have about color vision deficiencies?" Two people added clarification to their responses to item 7-3, "Book levels are indicated by color-

coding in my library," stating that just the fiction section is color coded for book levels and that "we no longer use AR."

When asked in item 10 for additional information about the use of color in the their libraries, one stated, "Designing Power Point slides, I always use high contrast colors so it is easier for everyone to read," and another said, "Again-I never thought about it in terms of color deficiencies."

As with the statewide questionnaire, the pretest included six categorical items related to knowledge of specific people with color vision deficiencies. Case study participant responses are presented in Table 13.

Table 13

Knowledge Items with Categorical Values - Case Study Pretest

Item #	Item	Number Yes	Percent Yes	Number No	Percent No
12	Have you ever been told by someone in the school that a specific student is color blind?	0	0	8	100
12-o	If so, what position did that person hold? (teacher, special education teacher, nurse, etc.)		Open response item		
13	Have you ever been told by a parent that a specific student is color blind?	0	0	8	100
14	Have you ever been told by a student that he/she is color blind?	0	0	8	100
15	Do you know anyone (other than students) with color vision deficiencies?	4	50	4	50
16	Have you ever suspected that a specific student is color blind?	1	14	7	86
16-o	If so, what did you do?		Open response item		
18	Have you attended any previous disability training (class, workshop, etc.)?	4	50	4	50
18-o	Was color vision mentioned?	0		4	

The six categorical value questions for the case study pretest revealed that none of the participants had been told by someone that a student had color vision deficiencies, but half of the participants knew someone other than a student with color vision deficiencies. In the interviews, some elaborated on this, stating they had never seen the issue of color vision deficiencies included on an IEP. Half of the participants indicated they had attended previous disability awareness training, but none of those four could recall color vision deficiencies being mentioned in the training. On item 16, one respondent indicated positively when asked, "Have you ever suspected that a specific student was color blind? If so, what did you do?" and stated "Assist them as much as I can."

Attitudes or understandings about color vision deficiencies

The second research question explored the attitudes and understandings of elementary school librarians as related to color vision deficiencies. Twenty-eight items in the questionnaire addressed this research question, based on similar constructs as the knowledge items:

- general attitudes or understandings about color vision deficiencies
- attitudes or understandings about students and experiences
- attitudes or understandings related to library design and instruction.

Table 14 shows the organization of these items in the design of the original questionnaire.

Statewide questionnaire. The attitude items were analyzed in the same manner as the knowledge items. Five statewide participants did not complete the questionnaire, skipping all of the attitude items, so the sample size for the attitude scale was 237, five less than the knowledge scale sample size. The overall group mean for the attitude items on the statewide questionnaire was 2.68, $sd = .232$, $N = 237$. Descriptive statistics were

calculated for each item in the attitude scale to explore the characteristics of each item, as seen in Table 14.

Table 14

Descriptive Statistics for Statewide Questionnaire – Attitude Items

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
4-3	Color vision deficiencies are discussed in Education courses in college	236	1.87	0.573	2	58
4-4	Color-coding is a helpful way to categorize information	234	2.96	0.579	3	7
4-5	Training about color vision deficiencies would be helpful for educators	236	3.17	0.498	3	11
4-6	I have thought about the needs of color vision deficient students before this survey	235	2.15	0.725	2	8
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	235	2.61	0.75	3	17
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	236	2.48	0.719	2	55
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	232	1.87	0.645	2	24
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	237	2.74	0.64	3	34
4-11	Teachers know if there are students in their classes with color vision deficiencies	235	1.96	0.549	2	43
5-1	People with color vision deficiencies know they see the world differently than others	237	2.42	0.627	2	60
5-2	People with color vision deficiencies learn to compensate on their own	237	2.8	0.49	3	39
5-3	People with color vision deficiencies should have a 504 or IEP	237	2.66	0.744	3	83
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	232	2.52	0.606	0	127
7-9	Adding the color name when color-coding is helpful	231	3.12	0.515	3	33
9-1	To what degree do you think color vision may affect reading a map	230	3.24	0.599	3	1
9-2	To what degree do you think color vision may affect reading a picture book	229	2.87	0.649	3	2
9-3	To what degree do you think color vision may affect reading a graph or chart	229	3.21	0.635	3	2
9-4	To what degree do you think color vision may affect finding a book on the shelf	230	2.44	0.722	2	3

Descriptive Statistics for Statewide Questionnaire – Attitude Items (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
9-5	To what degree do you think color vision may affect playing a board game	230	2.96	0.626	3	8
9-6	To what degree do you think color vision may affect completing a puzzle	230	3.14	0.65	3	3
9-7	To what degree do you think color vision may affect playing a game on the computer	229	2.97	0.588	3	9
9-8	To what degree do you think color vision may affect following directional signs in the library	230	2.37	0.761	2	9
11-2	If I suspected a student was color vision deficient, I would want to help him/her	229	3.44	0.541	3	6
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	229	2.3	0.713	2	27
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	228	2.53	0.699	0	151
11-5	Students with color vision deficiencies are receiving assistance/support from parents	228	2.6	0.661	0	165
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	228	2.51	0.658	0	149
11-7	Students with color vision deficiencies ask for help when needed	229	2.17	0.548	0	125

As seen in the table, the first item with a mean score over 3.00 was item 4-5, "Training about color vision deficiencies would be helpful for educators." ($\mu = 3.17$). Another item with a mean over 3.00 was item 7-9, "Adding the color name when color-coding is helpful." ($\mu = 3.14$). A series of eight questions asked the participants the degree to which they felt color vision deficiencies affected certain tasks. Of these eight questions, three had mean scores higher than 3.00.

- To what degree do you think color vision may affect reading a map ($\mu = 3.24$)
- To what degree do you think color vision may affect reading a graph or chart ($\mu = 3.21$)
- To what degree do you think color vision may affect completing a puzzle ($\mu = 3.14$)

Item 11-2 "If I suspected a student was color vision deficient, I would want to help him/her," had the highest mean score in the group ($\mu = 3.44$). Two hundred twenty participants either agreed or strongly agreed with this item. On the other hand, the item that followed, 11-3 "If I suspected a student was color vision deficient, I would know how to help him/her," had a much lower mean score ($\mu = 2.3$). One hundred thirty-eight participants either disagreed or strongly disagreed with this item.

Three items had mean scores lower than 2.00.

- Color vision deficiencies are discussed in Education courses in college ($\mu = 1.87$)
- The inability to identify colors may be due to carelessness, not color vision deficiencies ($\mu = 1.87$)
- Teachers know if there are students in their classes with color vision deficiencies ($\mu = 1.96$)

Five items in this group had modes of zero, meaning the highest number of respondents chose *do not know* as their response. The first of these was item 7-8 "Students with color vision deficiencies will ask other students for help in the library if needed." ($Mo = 0$, $n = 127$). Item 11-7 was very similar, but left out the distinction of asking other students for help, and had a similar response ($Mo = 0$, $n = 125$). The other items with a mode of zero were items 11-4, 11-5, and 11-6. This was a series of items about the support students with color vision deficiencies receive.

- Special Education teachers provide accommodations for students with color vision deficiencies ($Mo = 0$, $n = 151$)
- Students with color vision deficiencies are receiving assistance/support from parents ($Mo = 0$, $n = 165$)

- Students with color vision deficiencies are receiving assistance/support from teachers (*Mo* = 0, *n* = 149)

Item 5-3 "People with color vision deficiencies should have a 504 or IEP," also received a high amount of zero responses (*n* = 83), although just one less than the mode of 3. The majority of respondents either agreed to this item or responded *do not know*.

The researcher took note of the items with a high number of zero responses for close inspection when comparing the pre and post scores of the case study group.

On the open response items, some respondents wrote comments that were related to items in the attitude scale. When asked for additional thoughts related to color vision deficiencies, 32 of the 43 respondents made at least one comment about their attitude or understanding of color vision deficiencies. For example, many responses expressed a feeling that the study was important to education, such as "I think this is an issue that has been left out of the educational arena, so I'm glad that you are doing research into it." Others stated statements like "Honestly, I have never put that much thought into it in the educational setting."

Item ten asked for information about the use of color in the library. Many of the attitude-related responses to this item stated that the respondents were unaware of the issue or had not thought about the use of color before. The respondents again stated their intention of considering color differently in the future, such as, "This makes me think about the use of color in the library with different emphasis."

Item 17 gave participants one more opportunity to give information about their experiences with people with color vision deficiencies. While this item asked specifically about experiences which are included in the knowledge items, some respondents did

present attitude or understanding responses. Most of these responses were related to the importance of knowing about color vision deficiencies and making accommodations for those students who are affected. For example, "Accommodations need to be made in this area - for children and adults. Teachers and librarians need to be educated on meeting the needs of these students." More discussion of the open-response item responses is included in chapter five.

Case study pretest. The case study pretest consisted of the same attitude items as the statewide questionnaire. The overall group mean for the attitude items on the case study pretest was 2.73, $sd = .160$, $N = 8$. The researcher analyzed the data for the individual items in the attitude scale in the same manner, and the results are presented in Table 15.

Table 15

Descriptive Statistics for Case Study Pretest – Attitude Items

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
4-3	Color vision deficiencies are discussed in Education courses in college	8	2.00	.577	2	1
4-4	Color-coding is a helpful way to categorize information	8	3.13	.354	3	0
4-5	Training about color vision deficiencies would be helpful for educators	8	3.14	.378	3	1
4-6	I have thought about the needs of color vision deficient students before this survey	8	2.13	.641	2	0
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	8	2.75	.463	3	0
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	8	2.43	.535	2	1
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	8	2.00	.000	2	2
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	7	2.67	.516	3	1

Descriptive Statistics for Case Study Pretest – Attitude Items (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
4-11	Teachers know if there are students in their classes with color vision deficiencies	8	1.71	.488	2	1
5-1	People with color vision deficiencies know they see the world differently than others	8	2.20	.447	2	3
5-2	People with color vision deficiencies learn to compensate on their own	8	2.75	.500	0	4
5-3	People with color vision deficiencies should have a 504 or IEP	8	2.80	.447	3	3
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	8	2.25	.500	0	4
7-9	Adding the color name when color-coding is helpful	8	3.00	.000	3	1
9-1	To what degree do you think color vision may affect reading a map	8	4.00	.000	4	1
9-2	To what degree do you think color vision may affect reading a picture book	8	3.00	.817	3	1
9-3	To what degree do you think color vision may affect reading a graph or chart	8	3.71	.488	4	1
9-4	To what degree do you think color vision may affect finding a book on the shelf	8	2.29	.756	2, 3	1
9-5	To what degree do you think color vision may affect playing a board game	8	3.00	.577	3	1
9-6	To what degree do you think color vision may affect completing a puzzle	7	3.67	.516	4	1
9-7	To what degree do you think color vision may affect playing a game on the computer	8	3.14	.690	3	1
9-8	To what degree do you think color vision may affect following directional signs in the library	8	2.57	.787	3	1
11-2	If I suspected a student was color vision deficient, I would want to help him/her	8	3.38	.518	3	0
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	8	2.00	.535	2	0
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	8	2.67	.578	0	5
11-5	Students with color vision deficiencies are receiving assistance/support from parents	8	2.00	--	0	7
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	8	2.00	--	0	7
11-7	Students with color vision deficiencies ask for help when needed	8	2.00	.000	2, 0	4

As seen in the table, there were a number of items with mean scores over 3.25 in the attitude scale. Most notably, item 9-1 "To what degree do you think color vision may

affect reading a map," resulted in seven respondents answering 4, Strongly Affect. One respondent did mark 0, indicating *do not know.* Other items with high mean scores were 9-3, "To what degree do you think color vision may affect reading a graph or chart," (μ = 3.71) and 9-6, "To what degree do you think color vision may affect completing a puzzle" (μ = 3.67). The next highest mean score was item 11-2, "If I suspected a student was color vision deficient, I would want to help him/her" (μ = 3.38). As seen in the statewide results, the next item, "If I suspected a student was color vision deficient, I would know how to help him/her," had a much lower mean score (μ = 2.00). In these two items, most of the respondents stated they would want to help a student with color vision deficiencies, but would not know how to help.

Six items in this group resulted in fairly high mean scores, at or near 3.00:

- Color-coding is a helpful way to categorize information (μ = 3.13);
- Training about color vision deficiencies would be helpful for educators (μ = 3.14);
- Adding the color name when color-coding is helpful (μ = 3.00);
- To what degree do you think color vision may affect reading a picture book (μ = 3.00);
- To what degree do you think color vision may affect playing a board game (μ = 3.00);
- To what degree do you think color vision may affect playing a game on the computer (μ = 3.14).

Item 4-11, "Teachers know if there are students in their classes with color vision deficiencies," was the only item in this group that resulted in a mean score which was lower than 2.00, although several items did result in 2.00 mean scores.

Three items in this group had fairly high standard deviations, indicating a wide range of responses among the participants:

- To what degree do you think color vision may affect reading a picture book;
- To what degree do you think color vision may affect finding a book on the shelf;
- To what degree do you think color vision may affect following directional signs in the library.

As can be seen, these items all came from a group of items aimed at determining how strongly the respondents felt color vision deficiencies may affect various tasks in the school library.

There were six items that resulted in most of the respondents selecting 0, *do not know.*

- People with color vision deficiencies learn to compensate on their own;
- Students with color vision deficiencies will ask other students for help in the library if needed;
- Special Education teachers provide accommodations for students with color vision deficiencies;
- Students with color vision deficiencies are receiving assistance/support from parents;
- Students with color vision deficiencies are receiving assistance/support from teachers;

- Students with color vision deficiencies ask for help when needed.

Interestingly, five of these items were also the items in which the mode was zero in the statewide group.

Post-test results

Knowledge. Before analyzing the changes in pretest and post-test scores, the researcher ran scores of central tendency for the post-test in the same manner as was reported earlier for the pretest. The resulting mean score was 3.12, $sd = .147$, $N = 8$. Results from the individual knowledge items are shown in Table 16.

Table 16

Descriptive Statistics for Case Study Post-Test – Knowledge Items

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
3-1r	Color vision deficiency means the person sees everything in black and white	8	3.75	.463	4	0
3-2	There are careers which require normal color vision	8	3.88	.354	4	0
3-3	Color vision deficiencies are inherited conditions	8	3.50	.535	3	0
3-4r	Color vision deficiencies can be corrected with treatment	8	3.38	.518	3	0
3-5r	All people with color vision deficiencies see colors in the same way	8	3.50	.535	3, 4	0
3-6	Color vision deficiencies are more prevalent in males than in females	8	3.71	.488	4	1
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	8	1.86	.690	2	1
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	8	2.29	.756	2, 3	1
3-9	Background color may make it difficult for some students to read the words on a page	8	3.50	.535	3, 4	0
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	8	3.50	.535	3, 4	0
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	8	3.75	.463	4	0
4-2	Lighting can affect a person's ability to distinguish between colors	8	3.38	.518	3	0
7-1	I refer to color in pictures when reading books to students	8	3.13	.641	3	0

Descriptive Statistics for Case Study Post-Test – Knowledge Items (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	7	3.00	.817	3	0
7-3	Book levels are indicated by color-coding in my library	8	2.38	1.06	3	0
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	8	3.00	.707	3	3
7-5	The library website is visually accessible to all users	8	2.83	.753	3	2
7-6	I use instructional materials that have colors which are visually accessible to all students	8	2.86	.378	3	1
7-7	Color is a large component of whole group instruction in my library	8	2.13	.641	2	0
8-1	I consider the needs of students with color vision deficiencies when designing lessons	8	2.75	.463	3	0
8-2	I consider the needs of students with color vision deficiencies when decorating the library	8	3.00	.535	3	0
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	8	3.13	.641	3	0
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	8	3.38	.518	3	0

In the case study post-test knowledge items, one obvious result was the high amount of items with mean scores at or above 3.00. Sixteen of the 23 items fell into this category, as can be seen in the table above. This appeared to be in stark contrast to the pretest scores in this area.

Only one item in this group, Item 3-7, "Pure primary colors are usually distinguishable by people with color deficiencies," resulted in a mean score lower than 2.00 ($\mu = 1.86$).

Another striking result was the high amount of items in which no one chose zero to indicate they did not know. In the post-test, there were only six items for which anyone chose zero, a drop from the pretest in which 11 items included zero responses. All case

study participants showed a decrease in the amount of zero responses they gave from pretest to post-test.

Attitude. The attitude scale items on the post-test were analyzed in the same manner as the knowledge items resulting in a group mean of 2.62, $sd = .250$, $N = 8$. Descriptive statistics for central tendency of the individual attitude items are shown in Table 17.

Table 17

Descriptive Statistics for Case Study Post-Test – Attitude Items

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
4-3	Color vision deficiencies are discussed in Education courses in college	8	1.38	.518	1	0
4-4	Color-coding is a helpful way to categorize information	8	2.57	.787	3	1
4-5	Training about color vision deficiencies would be helpful for educators	8	3.29	.488	3	1
4-6	I have thought about the needs of color vision deficient students before this survey	8	1.88	.835	1, 2	0
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	8	2.88	.354	3	0
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	8	2.83	.408	3	2
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	8	1.75	.707	2	0
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	8	2.67	1.03	3	2
4-11	Teachers know if there are students in their classes with color vision deficiencies	8	1.75	.463	2	0
5-1	People with color vision deficiencies know they see the world differently than others	8	2.00	.000	2	0
5-2	People with color vision deficiencies learn to compensate on their own	8	2.75	.463	3	0
5-3	People with color vision deficiencies should have a 504 or IEP	8	3.00	.000	3	2
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	8	4.00	.817	0	4
7-9	Adding the color name when color-coding is helpful	8	3.25	.463	3	0
9-1	To what degree do you think color vision may affect reading a map	8	3.50	.535	3, 4	0

Descriptive Statistics for Case Study Post-Test – Attitude Items (continued)

Item #	Item	N	Mean	Standard Deviation	Mode	N choosing Zero
9-2	To what degree do you think color vision may affect reading a picture book	8	2.88	.354	3	0
9-3	To what degree do you think color vision may affect reading a graph or chart	8	3.50	.756	4	0
9-4	To what degree do you think color vision may affect finding a book on the shelf	8	2.50	.936	2, 3	0
9-5	To what degree do you think color vision may affect playing a board game	8	2.75	.463	3	0
9-6	To what degree do you think color vision may affect completing a puzzle	8	3.50	.535	3, 4	0
9-7	To what degree do you think color vision may affect playing a game on the computer	8	2.75	.463	3	0
9-8	To what degree do you think color vision may affect following directional signs in the library	8	2.25	.707	2	0
11-2	If I suspected a student was color vision deficient I would want to help him/her	8	3.63	.518	4	0
11-3	If I suspected a student was color vision deficient I would know how to help him/her	8	2.67	.818	2	2
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	8	1.80	.837	0	3
11-5	Students with color vision deficiencies are receiving assistance/support from parents	8	1.75	.500	0	4
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	8	2.00	.000	0	5
11-7	Students with color vision deficiencies ask for help when needed	8	2.00	.000	0	5

One item in this group, Item 7-8, "Students with color vision deficiencies will ask other students for help in the library if needed," resulted in a mean score of 4.00. However, half of the respondents chose zero, indicating *do not know* for this item, which also had a high standard deviation (sd = .817), indicating a high discrepancy between scores that were not zero. Only six other items had mean scores that were higher than 3.00 in this group:

- Training about color vision deficiencies would be helpful for educators (μ = 3.29)
- Adding the color name when color-coding is helpful (μ = 3.25)

- To what degree do you think color vision may affect reading a map ($\mu = 3.50$)
- To what degree do you think color vision may affect reading a graph or chart ($\mu = 3.50$)
- To what degree do you think color vision may affect completing a puzzle ($\mu = 3.50$)
- If I suspected a student was color vision deficient, I would want to help him/her ($\mu = 3.63$)

Equally important in these data are the items with low mean scores, under 2.00. Six items fall into this category:

- Color vision deficiencies are discussed in Education courses in college ($\mu = 1.38$)
- I have thought about the needs of color vision deficient students before this survey ($\mu = 1.88$)
- The inability to identify colors may be due to carelessness, not color vision deficiencies ($\mu = 1.75$)
- Teachers know if there are students in their classes with color vision deficiencies ($\mu = 1.75$)
- Special Education teachers provide accommodations for students with color vision deficiencies ($\mu = 1.80$)
- Students with color vision deficiencies are receiving assistance/support from parents ($\mu = 1.75$)

It is important to note the number of items with high standard deviations in the attitude scale items on the post-test. Ten items had a standard deviation over .700 in this group. Most notable, Item 4-10, "If a child cannot identify colors when tested, it may be

because he/she did not understand the test" (*sd* = 1.03) suggested the largest discrepancy among respondents. Table 18 shows the differences in responses on this item from pretest to post-test.

Table 18

Number of Responses for Each Score in Item 4-10 - Pretest and Post-Test

Score	N pretest	N post-test
1.00	0	1
2.00	2	1
3.00	4	3
4.00	0	1
0.00	1	2
Skipped	1	--

Another item with a very high standard deviation was Item 9-4, "To what degree do you think color vision may affect finding a book on the shelf," (*sd* = .936) although the standard deviation was fairly high on this item in the pretest as well (*sd* = .756).

Change in knowledge, attitudes, and behaviors

The case study activities were designed to explore the effect of participation in the color vision deficiencies awareness research activities on the knowledge, attitudes, and behaviors of the elementary school librarians from one school division. Data were collected using a variety of methods including observations, interviews, and blog postings. A training session was conducted with all librarians in the case study school division, including the elementary school librarians who were study participants. Data related to the change in knowledge and attitudes were collected from the quantitative results of the pretest compared to the post-test. Qualitative data from the other activities

provided richer detail and understanding. Changes in behaviors were explored through the observations, blog posts, and open-response items on the post-test.

Knowledge and attitude scale comparisons

In order to compare the group means of all members of the case study, a paired samples t-test was calculated to compare the mean of the pretest scores to the mean of the post-test scores in the two scales. The results are shown in Table 19.

Table 19

Pretest/Post-Test Comparison for Case Study Group - Knowledge and Attitude Scales

Individual test data			Paired differences				
Scale/Test	Mean	Standard deviation	Mean	Standard deviation	t	df	Sig. (2-tailed)
Knowledge/ Pretest	2.73	.129	.391	.190	-5.839	7	.001
Knowledge/ Post-test	3.12	.147					
Attitude/ Pretest	2.73	.160	.108	.294	-.137	7	.331
Attitude/ Post-test	2.62	.250					

The mean of the knowledge scale on the pretest was 2.73 (sd = .129), and the mean on the post-test was 3.12 (sd = .147). The increase in scores was found to be statistically significant for the knowledge scale questions (t (7) = -5.839, p<.05).

The mean of the attitude scale on the pretest was 2.73 (sd = .160), and the mean on the post-test was 2.62 (sd = .250). This was not found to be a statistically significant change from pretest to post-test (t (7) = 1.04, p>.05).

In order to determine which items may have contributed the most to the change in mean scores for the knowledge and attitude items, the researcher examined the pretest and post-test mean scores for each item within the knowledge scale and the attitude scale

then calculated the difference between the scores. The resulting scores from the knowledge scale are shown in Table 20.

Table 20

Change in Mean Scores Pretest to Post-Test - Knowledge Items

Item #	Item	Pretest Mean	Post-test Mean	Change Pre to post
3-1r	Color vision deficiency means the person sees everything in black and white	3.43	3.75	0.32
3-2	There are careers which require normal color vision	3.50	3.88	0.38
3-3	Color vision deficiencies are inherited conditions	3.00	3.50	0.5
3-4r	Color vision deficiencies can be corrected with treatment	2.67	3.38	0.71
3-5r	All people with color vision deficiencies see colors in the same way	3.00	3.50	0.5
3-6	Color vision deficiencies are more prevalent in males than in females	3.00	3.71	0.71
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	2.17	1.86	-0.31
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	2.33	2.29	-0.04
3-9	Background color may make it difficult for some students to read the words on a page	3.14	3.50	0.36
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	3.13	3.50	0.37
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	2.33	3.75	1.42
4-2	Lighting can affect a person's ability to distinguish between colors	3.25	3.38	0.13
7-1	I refer to color in pictures when reading books to students	2.75	3.13	0.38
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	2.88	3.00	0.12
7-3	Book levels are indicated by color-coding in my library	2.63	2.38	-0.25
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	2.00	3.00	1.00
7-5	The library website is visually accessible to all users	3.00	2.83	-0.17
7-6	I use instructional materials that have colors which are visually accessible to all students	3.00	2.86	-0.14
7-7	Color is a large component of whole group instruction in my library	2.29	2.13	-0.16
8-1	I consider the needs of students with color vision deficiencies when designing lessons	2.13	2.75	0.62
8-2	I consider the needs of students with color vision deficiencies when decorating the library	2.13	3.00	0.87
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	2.14	3.13	0.99
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	2.00	3.38	1.38

The largest change in mean scores showed up in Item 4-1r, "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school," where there was a change of 1.42 points. Similarly, Item 11-1r, "Color vision deficiency is classified as a disability under Special Education guidelines," resulted in a change of 1.38 points from pretest to post-test. A change of 1.00 point was seen in Item 7-4, "When color-coding, I provide the information in another way as well (shape, design, etc.)," however this was an item mentioned earlier due to the large change in zero responses. The mean scores were derived from only the items scored on the one to four scale and did not include the zero scores.

Three items (8-1, 8-2, and 8-3) addressed the extent to which the participants consider the needs of students with color vision deficiencies when carrying out certain tasks in the library. All three of these items showed a change in mean scores. The largest change was in Item 8-3, "I consider the needs of students with color vision deficiencies when designing Power Point slides," had a change in mean score of 0.99 points from pretest to post-test.

It is interesting to note that Item 7-4, "When color-coding, I provide the information in another way as well (shape, design, etc.)," the number of zero responses increased from pretest to post-test, when the zero responses for most of the other items decreased from pretest to post-test, as seen in Table 21. The only other item with an increasing number of zero responses was Item 3-6, "Color vision deficiencies are more prevalent in males than in females," which increased from no zero responses to one in the post-test.

Table 21

Change in Number of Zero Responses from Pretest to Post-Test - Knowledge Items

Item #	Item	Pretest N choosing Zero	Post-test N choosing Zero
3-1r	Color vision deficiency means the person sees everything in black and white	1	0
3-2	There are careers which require normal color vision	0	0
3-3	Color vision deficiencies are inherited conditions	3	0
3-4r	Color vision deficiencies can be corrected with treatment	5	0
3-5r	All people with color vision deficiencies see colors in the same way	1	0
3-6	Color vision deficiencies are more prevalent in males than in females	0	1
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	2	1
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	2	1
3-9	Background color may make it difficult for some students to read the words on a page	1	0
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	0	0
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	5	0
4-2	Lighting can affect a person's ability to distinguish between colors	0	0
7-1	I refer to color in pictures when reading books to students	0	0
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	0	0
7-3	Book levels are indicated by color-coding in my library	0	0
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	0	3
7-5	The library website is visually accessible to all users	4	2
7-6	I use instructional materials that have colors which are visually accessible to all students	5	1
7-7	Color is a large component of whole group instruction in my library	1	0
8-1	I consider the needs of students with color vision deficiencies when designing lessons	0	0
8-2	I consider the needs of students with color vision deficiencies when decorating the library	0	0
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	0	0
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	0	0

The items with the most marked decrease in zero responses were Item 3-4r, "Color vision deficiencies can be corrected with treatment," and Item 4-1r, "In Virginia, all children are

tested for color vision deficiencies as part of the vision screening before entering school." Both of these items had five respondents who indicated *do not know* in the pretest and none with this indication in the post-test.

In the post-test items related to knowledge, several of the item scores had high standard deviations, indicating a high level of discrepancy among the participants. For example, Item 7-3 "Book levels are indicated by color coding in my library," had a standard deviation of 1.06. Further analysis of the descriptive data for this item shows the wide range of responses, as shown in Table 22.

Table 22

Number of Responses for Each Score in Item 7-3 - Pretest and Post-Test

Score	N pretest	N post-test
1.00	0	2
2.00	3	2
3.00	5	3
4.00	0	1

This item was related to the use of color in the participants' specific library spaces, but it is interesting to see this large of a difference among schools within one school division. Also, the standard deviation was not this large for the pretest scores, indicating some change in responses from pretest to post-test.

Item 7-2, "Signage in the library uses high contrast colors (black/white; red/yellow)," also had a high standard deviation ($\mu = 3.00$, $sd = .817$) in the post-test, although this item also had a high standard deviation in the pretest ($\mu = 3.00$, $sd = .835$). While there was some change in the score distribution from pretest to post-test, the

change was not as great as in Item 7-3. Additionally, one participant skipped this item on the post-test which could have made a difference in the results.

The researcher looked at the individual items that made up the knowledge scale to determine which items had the greatest change from zero responses to a scaled number response. As shown in Table 23, Item 11-1r, "Color vision deficiency is classified as a disability under Special Education guidelines" had the greatest rate of change, with seven of the eight respondents originally choosing *do not know* and then responding with disagree or strongly disagree, which is the expected response. Interestingly, the one person who did not record zero in the pretest on this item originally chose agree, then changed to disagree in the post-test.

Table 23

Frequency of Zero Responses in Pretest and Post-Test - Knowledge Items

Item	Item	Pre	Post
3-1r	Color vision deficiency means the person sees everything in black and white	1	0
3-2	There are careers which require normal color vision	3	0
3-3	Color vision deficiencies are inherited conditions	0	0
3-4r	Color vision deficiencies can be corrected with treatment	5	0
3-5r	All people with color vision deficiencies see colors in the same way	1	0
3-6	Color vision deficiencies are more prevalent in males than in females	0	1
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	2	1
3-8r	Color vision deficiencies affect a very small percentage of the population in a school	2	1
3-9	Background color may make it difficult for some students to read the words on a page	1	0
3-10r	The name of a color (blue, green, etc.) means the same thing to all people	0	0
4-1r	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	5	0
4-2	Lighting can affect a person's ability to distinguish between colors	0	0
7-1	I refer to color in pictures when reading books to students	0	0
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	0	1
7-3	Book levels are indicated by color-coding in my library	0	0
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	0	3
7-5	The library website is visually accessible to all users	4	2
7-6	I use instructional materials that have colors which are visually accessible to all students	5	1
7-7	Color is a large component of whole group instruction in my library	1	0
8-1	I consider the needs of students with color vision deficiencies when designing lessons	0	0
8-2	I consider the needs of students with color vision deficiencies when decorating the library	0	0
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	0	0
11-1r	Color vision deficiency is classified as a disability under Special Education guidelines	7	0

On Item 3-4r, "Color vision deficiencies can be corrected with treatment," five participants originally chose zero, and all five changed to a scale number in the post-test. Again, all five changed to disagree or strongly disagree, which was the expected

response. The remaining three participants all gave the expected responses on the post-test, which was a change for one of the participants. Item 4-1r, "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school," had identical results, with all participants having the expected response in the post-test.

There were three items for which some participants changed from a scaled number score in the pretest to a zero response in the post-test. Two of the three were related to the specific libraries in the case study, item 7-2 addressing the signage in the library and 7-4 addressing color-coding. Three participants changed to a zero response on item 7-4, suggesting these participants had become unsure of their practices upon learning more about the topic. Interestingly, all three of these participants had originally chosen to disagree or strongly disagree on this item then changed to *do not know.* Of the 23 individual items in the knowledge scale, these three were the only ones with an increase in frequency of zero responses from pretest to post-test.

The largest change in zero response scores appeared in the case of Susan, who chose a zero response for nine of the knowledge items in the pretest and for only two items in the post-test. Although Susan did not complete all portions of the study, a change in knowledge is suggested through her decrease in zero responses.

As stated earlier, the mean scores for the attitude scale decreased from pretest to post-test, although the decrease was not statistically significant. The researcher compiled data for the attitude scale items in the same manner as the knowledge items, comparing mean scores on the pretest and post-test individual items to determine which may have contributed to the drop in the mean score. The results are displayed in Table 24.

Table 24

Change in Attitude Item Means Pretest to Post-Test

Item #	Item	Pretest Mean	Post-test Mean	Change Pre to Post
4-3	Color vision deficiencies are discussed in Education courses in college	2	1.38	-0.62
4-4	Color-coding is a helpful way to categorize information	3.13	2.57	-0.56
4-5	Training about color vision deficiencies would be helpful for educators	3.14	3.29	0.15
4-6	I have thought about the needs of color vision deficient students before this survey	2.13	1.88	-0.25
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	2.75	2.88	0.13
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	2.43	2.83	0.40
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	2	1.75	-0.25
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	2.67	2.67	0.00
4-11	Teachers know if there are students in their classes with color vision deficiencies	1.71	1.75	0.04
5-1	People with color vision deficiencies know they see the world differently than others	2.2	2	-0.20
5-2	People with color vision deficiencies learn to compensate on their own	2.75	2.75	0.00
5-3	People with color vision deficiencies should have a 504 or IEP	2.8	3	0.20
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	2.25	4	1.75
7-9	Adding the color name when color-coding is helpful	3	3.25	0.25
9-1	To what degree do you think color vision may affect reading a map	4	3.5	-0.50
9-2	To what degree do you think color vision may affect reading a picture book	3	2.88	-0.12
9-3	To what degree do you think color vision may affect reading a graph or chart	3.71	3.5	-0.21
9-4	To what degree do you think color vision may affect finding a book on the shelf	2.29	2.5	0.21
9-5	To what degree do you think color vision may affect playing a board game	3	2.75	-0.25
9-6	To what degree do you think color vision may affect completing a puzzle	3.67	3.5	-0.17

Change in Attitude Item Means Pretest to Post-Test (Continued)

Item #	Item	Pretest Mean	Post-test Mean	Change Pre to Post
9-7	To what degree do you think color vision may affect Playing a game on the computer	3.14	2.75	-0.39
9-8	To what degree do you think color vision may affect Following directional signs in the library	2.57	2.25	-0.32
11-2	If I suspected a student was color vision deficient, I would want to help him/her	3.38	3.63	0.25
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	2	2.67	0.67
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	2.67	1.8	-0.87
11-5	Students with color vision deficiencies are receiving assistance/support from parents	2	1.75	-0.25
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	2	2	0.00
11-7	Students with color vision deficiencies ask for help when needed	2	2	0.00

The mean scores on fourteen individual attitude items decreased from pretest to post-test. The item with the greatest decrease was item 11-4, "Special Education teachers provide accommodations for students with color vision deficiencies." However, it should be noted that zero (*do not know*) was the mode for item 11-4 in both the pretest and the post-test, indicating that most of the respondents were still unsure if accommodations were made by Special Education teachers. The item with the greatest increase in mean score from pretest to post-test was item 7-8, "Students with color vision deficiencies will ask other students for help in the library if needed." Again, this was an item for which half of the respondents chose a zero response, suggesting they were unsure about whether or not students would ask other students for help.

The post-test mean scores for attitude included eleven items for which no one chose a zero *do not know* response. This is in contrast to the pretest attitude items where only five items included *do not know* responses, as shown in Table 25.

Table 25

Change in Number f Zero Responses from Pretest to Post-Test - Attitude Items

Item #	Item	Pretest N choosing Zero	Post-test N choosing Zero
4-3	Color vision deficiencies are discussed in Education courses in college	1	0
4-4	Color-coding is a helpful way to categorize information	0	1
4-5	Training about color vision deficiencies would be helpful for educators	1	1
4-6	I have thought about the needs of color vision deficient students before this survey	0	0
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	0	0
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	1	2
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	2	0
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	1	2
4-11	Teachers know if there are students in their classes with color vision deficiencies	1	0
5-1	People with color vision deficiencies know they see the world differently than others	3	0
5-2	People with color vision deficiencies learn to compensate on their own	4	0
5-3	People with color vision deficiencies should have a 504 or IEP	3	2
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	4	4
7-9	Adding the color name when color-coding is helpful	1	0
9-1	To what degree do you think color vision may affect reading a map	1	0
9-2	To what degree do you think color vision may affect reading a picture book	1	0
9-3	To what degree do you think color vision may affect reading a graph or chart	1	0
9-4	To what degree do you think color vision may affect finding a book on the shelf	1	0
9-5	To what degree do you think color vision may affect playing a board game	1	0
9-6	To what degree do you think color vision may affect completing a puzzle	1	0
9-7	To what degree do you think color vision may affect Playing a game on the computer	1	0
9-8	To what degree do you think color vision may affect Following directional signs in the library	1	0
11-2	If I suspected a student was color vision deficient, I would want to help him/her	0	0

Change in Number of Zero Responses from Pretest to Post-Test - Attitude Items (continued)

Item #	Item	Pretest N choosing Zero	Post-test N choosing Zero
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	0	2
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	5	3
11-5	Students with color vision deficiencies are receiving assistance/support from parents	7	4
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	7	5
11-7	Students with color vision deficiencies ask for help when needed	4	5

As seen in the table, three items show an increase in the number of zero responses. Most notably, two respondents chose *do not know* for item 11-2, "If I suspected a student was color vision deficient, I would know how to help him/her," after participating in the training session. It is also interesting to note that one respondent chose *do not know* for item 4-4, "Color coding is a helpful way to categorize information," on the post-test. More discussion of the zero score changes in the attitude items is included in chapter five.

Table 26 shows the change in frequency of zero responses from pretest to post-test for individual items in the attitude scale.

Table 26

Frequency of Zero Responses in Pretest and Post-Test - Attitude Items

Item #	Item	Pre	Post
4-3	Color vision deficiencies are discussed in Education courses in college	1	0
4-4	Color-coding is a helpful way to categorize information	0	1
4-5	Training about color vision deficiencies would be helpful for educators	1	1
4-6	I have thought about the needs of color vision deficient students before this survey	0	0
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	0	0
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	1	2
4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	2	0
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	1	2
4-11	Teachers know if there are students in their classes with color vision deficiencies	1	0
5-1	People with color vision deficiencies know they see the world differently than others	3	0
5-2	People with color vision deficiencies learn to compensate on their own	4	0
5-3	People with color vision deficiencies should have a 504 or IEP	3	2
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	4	4
7-9	Adding the color name when color-coding is helpful	1	0
9-1	To what degree do you think color vision may affect reading a map	1	0
9-2	To what degree do you think color vision may affect reading a picture book	1	0
9-3	To what degree do you think color vision may affect reading a graph or chart	1	0
9-4	To what degree do you think color vision may affect finding a book on the shelf	1	0
9-5	To what degree do you think color vision may affect playing a board game	1	0
9-6	To what degree do you think color vision may affect completing a puzzle	1	0
9-7	To what degree do you think color vision may affect Playing a game on the computer	1	0
9-8	To what degree do you think color vision may affect Following directional signs in the library	1	0
11-2	If I suspected a student was color vision deficient, I would want to help him/her	0	0
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	0	2
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	5	3
11-5	Students with color vision deficiencies are receiving assistance/support from parents	7	4
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	7	5
11-7	Students with color vision deficiencies ask for help when needed	4	5

It is interesting to note that items 11-4, 11-5, and 11-6 all started with high frequencies of zero responses and did not have a large decrease. These three items were related to the accommodations or support students with color vision deficiencies are receiving from special education teachers, teachers, and parents. This suggests that a number of the participants were still questioning their attitude about this after participation in this study. Items 7-8 and 11-7 are the two items related to students seeking out help when needed. Again, half of the participants chose *do not know* in the pretest and at least half chose that response in the post-test.

Themes in case study observations and interviews

The researcher gathered data collected during the case study observations, interviews, and blog prompts. Qualitative data from all of the case study sites and participants were analyzed to discover emerging themes related to the research questions.

Color in library space

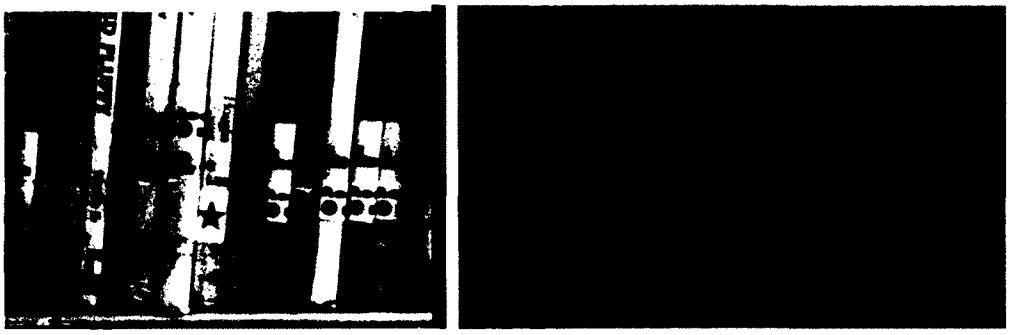
In the case study library space observations, the use of color was observed and coded for two purposes:

1. Use of color for organization/information;
2. Use of color for decoration/design aesthetic.

All of the cases had some use of colored labels on the books to give information about the books, such as reading level or genre. In some libraries the colored label coincided with the Accelerated Reader (AR) book level. None of the libraries with this use of colored labels included the reading level in another format on the spine. However, some did include more detailed AR information inside the book, as seen in Figure 7.

Figure 7

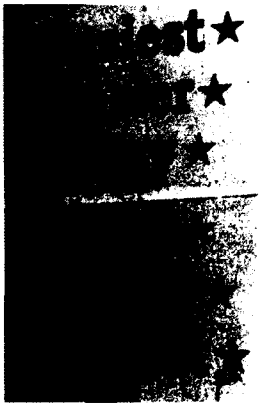
Spine Labels and AR Information



Another way of presenting the color code information was observed at Jackson Elementary School Library where a sign posted behind the circulation desk listed the codes for the various colors of spine labels, as seen in Figure 8. This form of signage required the library user to be able to differentiate between the colors without further visual assistance, such as the name of the color.

Figure 8

Book Level Color Chart

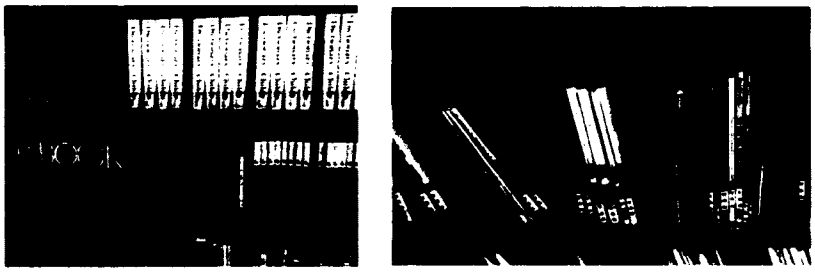


Some libraries used colored spine labels to designate different genres or areas of the library. For example, Washington Elementary School Library had yellow spine labels on all of the reference books. Likewise, the shelf labels in the reference section were

printed on yellow. Similarly, the picture books were all labeled with red spine labels. These color combinations provided high contrast for easy reading and the corresponding shelf labels presented the meaning of the colored labels, as seen in the images below.

Figure 9

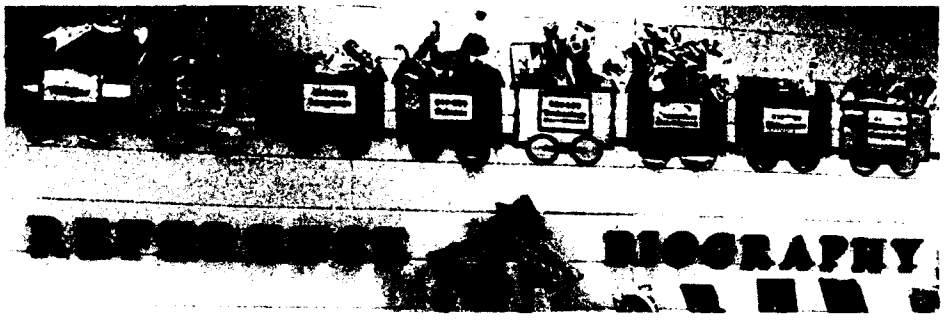
Colored Spine Labels



The second purpose of color in the library spaces was for decoration or design aesthetic. Color was coded for this use if the color itself did not give information but instead contributed to the overall look of the item or the library. For example, color choices on library signage did not usually give information; colors were chosen for aesthetic purposes. Most of the signage observed consisted of high contrast colors, such as white text on a dark background or vice versa. Two examples of high contrast signs are shown in Figure 10. In this example, contrast is maintained in the colored train cars by including a white background for the text area of the sign, making the information on the signs visually accessible.

Figure 10

High contrast signage



Observations, interviews, and blog prompts

Some major themes emerged as the qualitative data from the observations, interviews, and blog prompts were analyzed. As was evident from the questionnaires, the data suggested a statistically significant increase in knowledge from pretest to post-test. One theme in the qualitative data reflected this change, as the case study participants shared their change in knowledge through the course of the study. Only one participant shared any more than a very basic understanding of color vision deficiencies, such as "just the fact that some people are color blind and that they can't differentiate." At the interviews early in the study, the other eight participants said they had "very little understanding of it," and "I have no knowledge," or "I know nothing...that it exists, I guess." However, there was an observable change in their awareness as they went through the pieces of the study, some evident during the early interviews and verified by later blog responses. For example, Angela indicated early in the interview that she had "little understanding" of color vision deficiencies, but later in the interview she stated "Now I'm sort of more aware and just seeing if someone goes to sit somewhere else when I say 'sit on the yellow corner.'" At the end of the interview, Angela was thinking about how color vision deficiencies may be misinterpreted in the classroom:

> But think about it. I, let's say they can't do something because they can't see the color so it means nothing to them and the teacher thinks that they're just fooling around. You know that's going to cause a huge problem, when they're not...they don't see it that way.

Other participants showed similar change throughout the study, sharing in the blogs posts statements such as, "I was really surprised at the pervasiveness of color deficiencies in boys. Because of the training, I am more aware of potential issues as I plan my lessons." Janice stated, "You've made me start thinking about something that I haven't, that hasn't really come across my mindset yet, so that's good."

Another theme that arose related to knowledge of color vision deficiencies was about testing and accommodations for color vision deficiencies. The case study participants stated that color vision deficiencies were not included in IEPs or other information provided to the librarians. Thelma said, "I've never seen color blind come across on an IEP." Emily said, "I've never been told that a student had a color vision deficiency and I haven't, from what I can remember, noticed it on my own either." Lottie said, "In 30 years I've never been told that anyone had color deficiency. Now my question is, do some people in our school know more that they're telling me? I never knew to ask." This line of conversation led to the next theme that emerged in the interviews.

The participants talked a lot about how they found out information about the needs of specific students, and the researcher was surprised to find a great discrepancy in what information was shared at each school. All of the librarians talked about meeting with either the school nurse or special education teachers to gather information about

special needs. Some received full IEPs from the special education teachers while others only received an abbreviated form, often referred to as an "IEP at-a-glance." The greater discrepancy emerged in the medical information shared. While all stated that the school nurse was very helpful and happy to share information if asked, many said something similar to "the nurse can't give us a paper that says these kids have these issues because of a privacy clause." Another participant said she was only provided with medical information "on a need to know basis." She also stated that the classroom teacher is often given background information that is not shared with resource teachers because the resource teachers are not the "primary teacher." The discrepancy between schools within the same school division was surprising to the researcher.

Another theme that emerged in the qualitative data was related to differentiating instruction and making accommodations within the library. In the interviews, the participants gave many example of how they differentiate their lessons to meet the needs of a variety of learners, such as adapting their lessons to include a variety of learning styles. Because of their lack of knowledge about color vision deficiencies early in the study, the participants shared concern about meeting the needs of learners with color vision deficiencies. This was shared best by Lucy, who said, "Well, it's that need to know. What do we need to know? We need to know how to accommodate for it. That's our need to know." She went on to talk about the amount of activities in the library that include color, especially in the primary grades, and said, "I can't even guess how many kinds I've had that have had issues with that. I've never really known it or done anything about it."

Change for case study participants

The researcher explored the results for the individual cases to determine any change in each participant throughout the course of the research study. The pretest and post-test scores were analyzed as well as the qualitative data collected from the observations, interviews, and blog postings to provide a clear picture of each case. Detailed descriptions of the nine individual cases are presented in Appendices P - W.

Angela. Angela showed a considerable change in knowledge from the pretest (μ = 2.79) to the post-test (μ = 3.39). Her change in knowledge was apparent in her blog postings and interview comments. In the post-test she wrote that the training session "made me more aware of the need for high contrast signage and to refer to things in other ways than just color." In the blog post she commented, "I did not realize that there were so many different types of color vision deficiencies. Also, I had a realization as to what people with color vision deficiencies actually 'see'." She described a new observation she made since the training in a later post:

> I noticed that one of my kindergarten boys was referring to colors in an unusual way. I do not recall exactly, but he said that something was gray when it clearly was not. I think that I am now more aware of the reasons why students might refer to a color in a certain way. Prior to the training I presumed that the student did not know their colors correctly. Now I am aware that there could be a vision deficiency...I think that sometimes we blame kids for "being lazy" or in a hurry, but it could be something else entirely.

It is apparent through the description above that Angela's attitudes or understandings of students with color vision deficiencies are changing along with her knowledge. She reports thinking about the needs of the students differently and reacting to their responses in a new way. "It helps me to understand, maybe some of the ones who seem really confused, that there could be a reason. It's not that they're doing it willfully, it's because they don't see it as red."

Naire. The pretest and post-test did not show much change in either knowledge or attitude for Naire. The greatest change in Naire came from the observations. In the first observation, she did not provide many clues when asking questions about pictures. Her questions included, "What is this?" and "What is this a picture of?" When referring to colors in a book, she said, "Let's look at the color of this book. Notice the colors. Somebody tell me what colors there are." In the second observation Naire included clues about the pictures she was showing and provided scaffolding as was discussed in the training session. She often gave the color of a picture and asked the students for another attribute such as shape or a name of an object. "This is green. Can you think of a fruit or a vegetable? What are you thinking of when you think of green?" She commented about her learning in the post-test, writing, "I love learning so this information was helpful...and made me aware of color vision deficiencies and how I can change the way I respond to students." Naire's changes in behavior reflect the suggestions made in the training session and provide evidence of her growth through participation in the study.

Thelma. Thelma was the only participant in the case study to share a personal connection with someone who has color vision deficiencies. Even with this prior knowledge, she still showed a change in knowledge and in attitude. She stated in the

post-test that she is now "more aware and alert to students who respond incorrectly to color questions." In the interview she shared concern about student information that is not shared with all educators in the school and said in the post-test, "It would be helpful to know if a child has color vision deficiencies." When sharing stories in the post-observation, she spends a lot of time talking about the story and the pictures as they are reading, checking to make sure students are understanding what is going on. For example, on one page of a story, she stops and asks, "Where is Millie hiding in this picture? How did a cow get up in the tree? I don't know, but let's look what happened to all the mail." In this example, she guides the reader to the next part of the story and something new to look for in the pictures. In a blog post she shares,

> I learned the extent of how many boys have color deficiency and am floored by the thought of how many go undiagnosed. I also have a better understanding of the everyday ways it can affect a person. In my library, I have started being more aware of contrast when publishing information and developing library stations.

Emily. In the pre-observation, Emily used strategies that the researcher would suggest as accommodations for students with color vision deficiencies. For example, when reading the story she described each picture. Then in the activity which required students to choose a color that described a feeling, she walked to each color and named it to show the students where the colors were located in the room. In the training session, she shared that the next time she does this activity, she will go a step further and add the color word to the piece of paper so students could see the name of the color as an additional form of scaffolding. In the blog post, she wrote,

> One thing I learned is that having a certain color deficiency (red-green, for example) doesn't mean that you just can't differentiate between those two colors. Because of the way colors are mixed, it means that any number of colors could appear to be the same. I also learned that there is no accommodation for color deficiencies in either IEPs or 504 plans.
>
> One thing I plan to use in my library is the website that allows you to check images and web pages to see what they would look like for people with various color deficiencies.

She later shared a story about her morning news crew at the school and their use of color to differentiate the parts of the script. She said, "We talked about going back to just two colors and making sure to distinguish the two parts in a different was as well, with spacing."

Lucy. At the beginning of the post-observation, Lucy showed a desire to change to meet the needs of students with color vision deficiencies. She spoke to the researcher about some changes she noticed that needed to be made, and asked for advice on making the lesson in the observation more accessible to those with color vision deficiencies. In the interview, she described the difficulty of knowing if a child may have color vision deficiencies: "A lot of our kids come to us with a lack of background knowledge. You know, who knows. But this point in the year you'd think they would know their colors." She also talked about the pervasive use of color in an elementary school library:

> It's nothing I've ever given thought to and it's something we do all the time. And like you said color coding, I mean, our chapter books, we say go look at the yellow. They know they're the yellow labels, you know. I

> mean they're in a different spot, but still. Everything is color, you know the Franklin Elementary School resource books, they have the blue labels. Everything's color coded and I never think about that.

In a blog post, she agreed with another librarian about the need to make new signs in the library, showing her desire to change this aspect of the library environment.

Lottie. Lottie showed the most enthusiasm and concern about making changes in her library program and instruction. At the post-observation, she showed the researcher the new books and materials she ordered about color vision deficiencies. She expressed desire to increase the students' awareness of the condition by making the new materials available for students to check out and browse during their free reading time in the library. In the interview, she shared her thoughts about the use of color in her library to identify book levels within the Accelerated Reader program:

> I also looked around the library, and said we have colors in AR. And I say "get a book on your color." And for a child not to see the colors, I just would hope they'd say "We're confused." But no child's ever done that. They just pull the color. But I did think, we do AR colors; that's a big thing. And I read a lot of stories and we talk about illustrations and illustrators, so...I'm interested.

She also mentioned she planned to talk to the school nurse to find out if there were any students in the school with known color vision deficiencies. She expressed her shock when finding out that 8% of males have some form of color vision deficiency, saying "Holy cow! I think that's huge! I would think maybe one percent of the population. But at

least doctors, pediatricians should tell parents, or somebody should tell parents to ask for a test."

Janice. In the interview, Janice expressed great interest in learning more about color vision deficiencies and about UDL principles. During the interview she said, "If you're designing every lesson with a goal of trying to provide many different avenues for students to access that material, that would be good because you don't always know the complete history of every student that comes in every class." In the post-test, she said the training "opened up a whole new era of knowledge," and that she had been using UDL principles in her lesson design since the training. According to Janice, the signs in her library already used a combination of color and text or images, but she planned to make sure that all signs and instruction were done that way. She stated that she had recently suspected a student of having color vision deficiencies because of the information she learned in the training, and she planned to meet with the teacher to see if she noticed it as well.

Susan. Susan participated in the pre-observation, training, pretest, and post-test. She opted out of the other elements of the study. Even so, her pretest and post-test showed a change in her knowledge and attitudes. On the pretest, she responded to many items with "do not know," and changed most of her responses to a level of agreement or disagreement on the post-test. In the post-test she stated that she does think about the use of color more since the training.

Summary

The results of the study show elementary school librarians have limited knowledge about color vision deficiencies and are interested in learning about the condition and about accommodations that can be made to provide a more accessible learning environment. Those who participated in the case study showed a statistically significant increase in knowledge from pretest to post-test. Interestingly, there was not a significant difference in the attitude scale. This brings attention to the influence of zero responses which were coded as missing data.

Changes in the amount of *do not know* responses from pretest to post-test showed a change in thinking among the case study participants, although the rate of zeros did not always decrease. There were instances when the participants chose *do not know* as a response in the post-test for an item which was coded as a score response in the pretest. Overall, the rate of zero responses decreased in the knowledge scale for the case study participants. This suggests a change is occurring in the case study participants over the course of the study. Comments made by the participants back up this assertion and point to a change in knowledge coupled with a desire to change behaviors over time.

In the following chapter, the results of the study will be discussed in relation to the literature about color vision deficiencies. Implications for practice will be presented based on the findings of this study, and ideas future research will be presented.

CHAPTER 5

DISCUSSION

In this chapter, the researcher will discuss the findings of this research study in more detail, including a summary of the study, theoretical implications, unanticipated findings, implications for practice, and suggestions for further research. Results of the study suggest that the elementary school librarians in the study began the questionnaire with a low level of knowledge about color vision deficiencies. The case study participants' knowledge increased throughout the study, and the librarians indicated they wanted to know more about how to make changes in the library space and instruction to be more accessible to learners with color vision deficiencies. However, the participants indicated they have not been given instruction about color vision deficiencies until participating in this study.

Knowledge about color vision deficiencies

The questionnaire completed by the statewide study participants and as a pretest in the case study included 23 items designed to glean what elementary school librarians knew about color vision deficiencies. Before analysis, some items were reverse coded so a high score would represent the expected response. For example, for item 4-1, "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school," the expected response was "strongly disagree" since this is not a mandated test in Virginia.

The statewide study mean for the knowledge scale ($\mu = 2.82$) was just above the median of the one to four scale, as was the mean for the case study knowledge scale on the pretest ($\mu = 2.73$). Possibly more telling was the amount of participants who chose *do*

not know as an option for the knowledge items. There were multiple items within the knowledge scale for which a large number of respondents responded with *do not know* as presented in the results. In a 1998 study, Gallo, Panza, and Viviani stated that color vision deficiencies are "not understood and rarely recognized by the general public and educators" (Gallo et al., 1998). This statement is reflected in the statewide study results which suggest there is not a clear understanding of general knowledge related to color vision deficiencies among this sample of elementary school librarians in Virginia. Some responses in the open response items included, "I know very little about this topic of color vision deficiencies," and "Sorry to say, I don't know much about it...I have never been approached or read an IEP that indicated that a student had this issue." While a many questionnaire respondents stated they would want to help students with color vision deficiencies (μ=3.44), they did not feel they would know how to help the students (μ=2.3).

It appears that a relatively high percentage (63%) of respondents reported a personal connection with someone with color vision deficiencies other than a student. However, many gave information in the open response items that suggested they had not made the connection from their personal experience to the students in the library. One who said her husband is colorblind said, "I had not thought about how colorblindness impacts students in the library." Another said, "I had not considered this, and I do know people who are colorblind. This will make me more aware of using color."

There were responses that spoke to the importance of this issue from the perspective of those who have a close connection. One person shared, "My father and son both have color vision deficiencies. I discovered it when my son was in kindergarten and

still struggling with colors. While both have managed, color vision can still be an issue." This is similar to Gallo's findings that very few of the boys in his study knew they had a color vision deficiency nor were the teachers aware of the condition (Gallo, 1998). Cole (2004) suggested that students with color vision deficiencies be made aware of their condition and be given advice to help them choose appropriate career paths and other life choices. One example came from a questionnaire respondent:

> I have a close friend who is colorblind. He learned over time how to deal with this deficiency. He would hook his socks together before washing them so they stayed together and matched color. He hung his clothes in certain places by color. He was not afraid to ask for help distinguishing colors.

In order to teach this resiliency, educators must first be aware of color vision deficiencies and problems that may be caused by the condition. Then the condition must be detected and acknowledged by the school personnel and parents of the affected students.

Attitude or understanding about color vision deficiencies

The questionnaire included 28 items written to ascertain how elementary school librarians felt about color vision deficiencies or how they understood those feelings or beliefs. This scale of items was referred to as "attitude" in the results. While all of these items were written positively, it was difficult to predict how people would respond on a scale of strongly agree (or affect) to strongly disagree (or affect). The option for *do not know* was provided on this set of questionnaire items as well.

As presented in the results chapter, many participants reported that just completing the questionnaire caused them to think about an issue that had otherwise not

been considered, suggesting a heightened awareness of color vision deficiencies among those in the sample. Respondents to the open response items indicated their new-found interest in the topic and desire to learn more:

> "Interesting survey topic. One I have not considered in 34 years of teaching. I hope you share your findings with educators."
>
> "I think this is an issue that has been left out of the educational arena, so I'm glad you are doing research into it."
>
> "I feel that there are probably a lot of students who have color vision deficiencies that are undiagnosed. I would be interested in knowing how this would affect student learning."

One questionnaire respondent shared an opinion of the importance of this study:

> My husband is color blind and to this day denies it because his sister told him when he was young that if he just tried hard, he could see red. He has had many embarrassing moments due to this problem. He seems to see it as some kind of a 'moral failing' to be colorblind. I wish that he did not feel so stigmatized.

Change in knowledge, attitude, and behavior

This case study allowed the researcher to explore how a small group of elementary school librarians from one school division used color in their libraries and in their instruction. A training session was provided for all librarians in the school division, and those participating in the case study provided data about their knowledge, attitudes, and behaviors before and after the training session. These data allowed the researcher to identify any change in the participants related to the topics of the study.

As presented in the results, the case study participants' change in knowledge about color vision deficiencies throughout the study was statistically significant. A theme that emerged through the analysis of the qualitative data was an increased awareness of the issues surrounding color vision deficiencies. Most of the case study participants expressed little to no knowledge about color vision deficiencies in the pretest, and the growth in awareness was apparent as the study progressed. Participants began expressing the changes they noticed in their own knowledge and attitudes as early as the open response items in the questionnaire.

The case study participants also talked about their changing knowledge and attitudes in the interviews. Most of the librarians in the case study expressed little to no knowledge of color vision deficiencies or of anyone with the condition. In Angela's interview, her changing thought process is apparent through her responses to the interview questions. Near the beginning of the interview she says, "I have very little understanding of it." Later she adds, "Now I'm sort of more aware of it. Now I notice an awareness, more of an awareness." Near the end of the interview, Angela begins considering the issue in more depth:

> But think about it. If, let's say they can't do something because they can't see the color. So it means nothing to them, and the teacher thinks that they're just fooling around. You know that's going to cause a huge problem, when they're not, they don't see it that way.

This exemplifies Dwyer's (1991) concern that color vision deficiencies may be misinterpreted by teachers. Lucy also addressed this concern in her interview, when she said,

> I have not accommodated for the kids that I'm sure have had [color vision deficiencies], and I haven't known I've had. And it kind of made me feel momentarily bad in a way that I had never thought of that. I mean, I try to think of their needs, and I didn't. I've never thought of that.

After the training, Lucy's comment on the blog post suggested she progressed even further in her understanding of the needs of students with color vision deficiencies, "Because of the training, I am more aware of potential issues as I plan my lessons."

While a significant change occurred in the knowledge scale from pretest to post-test among the case study participants, the change was not statistically significant for the attitude scale, as reported in the results. Based on Festinger's Theory of Cognitive Dissonance, this could be an indication that the change which has taken place in the knowledge of the participants is causing some unsettled attitudes. The number of participants with changes from a scaled number response to a zero response, indicating *do not know* on items that were previously "known" suggests this. As their knowledge is changing, the data suggest they are becoming less sure of how they interpret and understand what is done to meet the needs of learners with color vision deficiencies. They are beginning to question their behaviors, a condition that could lead to future change.

In fact, Lottie and Lucy both shared information with the researcher at the post-observation about changes they were making in their libraries. Lottie described books and materials she had purchased about color vision deficiencies. She expressed a desire to increase the awareness of color vision deficiencies among the students in the school. Lucy talked about changes to the way she designed her lessons and the way she described

items in the library, now being sure to include more than just the color in her descriptions. Changes in the physical space were not seen by the researcher in the post-observations. However, as with any professional development that takes place in the middle of a busy school year, it may take time to see changes in the physical space, such as updated signage, but many of the case study participants expressed an interest in making necessary changes after analyzing their current signage and displays.

Theoretical implications

As stated in chapter one, Festinger's Theory of Cognitive Dissonance provided the underlying framework for this study. One element of cognitive dissonance is that of inconsistency (Gawronski, 2012). Cognitive inconsistency can be seen within the results of this study, most notably in the attitude scale results. There was not a significant change in the overall attitude scale score; however, change was evident in individual attitude items, including some unexpected changes to *do not know* responses. This suggests cognitive inconsistency among the participants. While many of the case study participants stated they had not made any changes to the library environment by the time of the post-observation, many did indicate the desire to make changes in the future to make their environment more accessible to students with color vision deficiencies. This exemplifies the conditions for making a change based on cognitive inconsistencies as described by Gawronski (2012), "Participants try to resolve the inconsistency between their general beliefs and their thoughts about past behavior by changing their behavior" (p. 656). As their knowledge changed through the course of the study, their attitudes changed, leading to the desire to change behavior.

The framework for the training session was the concept of Universal Design for Learning (UDL). This model was described in the training as a beneficial way to design instruction so it is accessible to students with a wide variety of needs, thereby making instruction more accessible to all learners. The participants in the case study frequently mentioned that they did not know about the needs of students in the school, including those with color vision deficiencies. Armed with new knowledge about the needs of students with color vision deficiencies, UDL allows educators to design their instruction and learning environment to be accessible to these students without further accommodations. This is of particular importance since color vision deficiencies often go undetected and screening for the condition is not routinely done in many states including Virginia.

Janice mentioned UDL in the interview, saying, "I like the concept of Universal Design, because that will hit a lot of different [needs], not only students who are dealing with color vision deficiency, but help other learners too who are struggling." In the post-test open response items, she expressed a "desire to create all of my lessons following the Universal Design template. When designing handouts and/or signage, making sure when using color that there is enough contrast and not relying solely on color to designate information." UDL is a framework that can be of great value to school librarians as they are designing their library programs to meet the diverse needs of the entire school community.

Unanticipated findings

One theme that emerged from the interview data was related to the information school librarians received about the needs of students in the school. The school librarian

is one of a group of educators in an elementary school (resource teachers) who have the opportunity to work with all of the students every year. However, the librarians are often not informed of specific needs of students they teach on a regular basis. Among the seven participants in the interviews, there was great inconsistency about something as simple as being told about the special education needs of students with Individualized Education Plans (IEP). While all said they met with the special education teachers early in the year to review needs of students and most said they receive notes or an "IEP-at-a-glance," which is an abbreviated outline of the students' needs, one said she does not receive anything in print, and another said she also receives the full IEP. Possibly more alarming is the way in which medical needs are shared within the school. Again, most indicated meeting with the school nurse at the beginning of the year, but some also stated that the nurse is not allowed to provide the information in print. Thelma said, "She can't give us a paper, so we take notes on allergies and asthma, and if there's epilepsy or seizures or something, we take notes on that type of thing." She later said,

> The nurse can't give us a paper that says these kids have these issues because of a privacy clause. And a lot of times that's the case, where there's a privacy issue. The teacher can know, but they don't consider centers people as the primary teacher so we don't always necessarily get all the background that we should.

Lucy said the same thing, "The school nurse provides us with the information that we 'need to know.' And it's all about what do we 'need to know.'" She explained that her in her school, "it has been determined that it's the classroom teacher's responsibility to make sure that everybody who needs to know does know."

This finding is important because color vision deficiencies, as described by Tofts (2003), can be categorized as a "hidden disability." An IEP does not typically include this information, but it might be included on a medical report if the condition is known. However, would this be an issue that the elementary school librarian would, as Lucy described, "need to know?" As a parent of boys with color vision deficiencies, I tell the core teachers about their needs every year, write it on their medical records, and have even ensured it is included on their IEPs (for other learning disabilities) as background information. I trust that someone is passing the information on to the other educators in the building, but the comments from the librarians in this case study suggest that may not be happening.

There was not a control group for this pre-experimental study, making it difficult to determine that any change was due to the training session alone. In fact, many participants reported a change in their thinking just after taking the questionnaire. The researcher received emails from librarians in the state who had completed the questionnaire. One wrote, "Just want to tell you how useful I found this survey...it really raised my awareness of students who might potentially be color blind, and how I can be more aware and sensitive to their needs. Thank you!" Similar responses were written in the open response items on the statewide questionnaire. In retrospect, the researcher could have given the pretest and post-test to the other librarians in the case study school division who were not part of the case study but did participate in the training session. These data would have provided insight about the effect of the training session alone, as compared to the effect of participation in the full study. As it was designed, the

researcher was only able discuss any change in the participants to their participation in the study as a whole, not as an effect of the training.

Limitations

One possible threat to internal validity in this study is the possibility of selection bias. While the researcher sent the statewide study to all elementary school librarians in Virginia for whom contact information could be found, the response rate was low and the sample was made up of voluntary participants. It is difficult to determine if the sample was representative of the larger population of elementary school librarians in Virginia or if those who responded were different in some way. For example, the large amount of participants who indicated they had a personal connection to someone with color vision deficiencies suggests those who responded may have been motivated to do so based on a personal connection to the topic.

Another possible threat to internal validity is test mortality given the length of the questionnaire. The researcher prepared for this by designing the questionnaire to consist of small groups of related items, allowing the participants to move through the items fairly quickly. The online access and submission of the questionnaire was also designed to make completion easier. There were some participants in the sample who responded to part of the questionnaire but stopped before it was completed. Given the anonymous nature of this portion of the study, it cannot be determined if those who did not complete the questionnaire were different from those who did complete it.

Possible threats to external validity include interaction of selection and treatment as well as interaction of setting and treatment. The sample in this study consists of a fairly homogeneous group of mostly female elementary school librarians. Making

generalizations from the data beyond this group is not possible. Instead, further research should be conducted with different groups and results compared to see if there are commonalities.

The questionnaire in this study was designed by the researcher, reviewed by experts in the field of school librarianship, and piloted with a small group before being used in the study. However, the questionnaire has not been tested in any other settings. In order to increase content validity, the researcher created a table of specifications before writing the items for the questionnaire. The table was then used to determine which questionnaire items would be included in the two scales, knowledge and attitude.

A limitation in the case study portion of this study was the limitation of only using information from the librarians in the study and not collecting any data from the students. The researcher had to be very diligent to make sure no student verbiage was included in the transcriptions even when it would have provided rich data for the study. Also, because the researcher had former professional ties to most of the participants, care was taken to remain a neutral observer even when it was clear that another set of adult hands would have been helpful with a group of kindergarteners in the library.

In order to keep the observations as natural as possible, the case study participants were given very little information about the topic of the study before the initial observations. The participants were told they did not need to plan a special lesson or do anything differently than they would normally plan. However, this led to lesson observations that were not necessarily tied to the topic of color. While this natural setting was a goal of the researcher, it would have been helpful if at least the post-observation

had been a lesson about color to determine if any of the strategies discussed in the training session were implemented in the lesson.

The training session provided to the school librarians was limited to just one half-day session that took place in the afternoon following a morning meeting. The researcher extended the learning from the training by using the blog prompts, but participation in the blog was limited. A follow-up workshop or webinar in which the participants could create some materials or write some lessons following the UDL model would enhance the training.

Implications for practice

As evident in the responses in this study, elementary school librarians are not aware of students with color vision deficiencies within their schools. Since the screening for the condition is not mandated in Virginia, it is not routinely done when students enter school. Requiring the screening would be an easy change to make and would be logical given the possible impact on daily tasks for those who have color vision deficiencies. However, screening is just the first step in addressing the needs of students with color vision deficiencies. Once the condition is known, educators need to be knowledgeable about color vision deficiencies and be equipped with strategies that will help students with the condition.

As shown in this study, just increasing the awareness of the participants made a difference in their desire to learn more and make changes. An awareness training session would provide the needed knowledge about the condition and could lead to a change in attitude. Follow-up sessions in which educators shared resources and ideas of how change has been implemented in the schools would keep the educators interested and

thinking about the topic. Of the participants in this study who stated they had attended a disabilities awareness training, the majority said color vision deficiencies were not covered in the training. A condition that affects such a significant percentage of students is certainly worth learning more about.

Among school librarians, an increased awareness about the needs of students with color vision deficiencies followed by suggestions for making changes would allow the librarians to meet the needs of this group of library users. As mentioned by the case study participants, school librarians are not always informed about the needs of the students, and it would be difficult to know the needs of every students. Since there is a great likelihood that there are students in a given school with color vision deficiencies, it makes sense for librarians to set up the learning environment to be accessible to any students with color vision deficiencies, whether known or unknown. Because of the unknown factor, it is even more important that the library program and instruction be designed to meet the needs of as many students as possible without having to make adaptations after students arrive in the library.

Universal Design for Learning is a great model on which this idea can be built. UDL principles guide the librarian in designing the program and the lessons with diverse needs in mind so accommodations are anticipated before the students come through the door. In a profession that encourages welcoming all learners, this is an ideal solution. The use of color in the library is one area in which the librarian can set up the library program so all students can access the information and be successful. Using multiple ways of presenting ideas and information, rather than relying on color alone, would expand the access to the information provided through color without interfering with those who have

normal color vision. Lucy's new description of her book cart, "the purple smiley face cart" is an example of presenting information in multiple ways. When the librarian thinks universally, ideas such as this are designed before the students come in for a lesson and become part of what the librarian is planning rather than an afterthought to meet the needs of a learner. The librarian becomes proactive instead of reactive, creating a more welcoming environment.

Some simple changes can be made in the school library that would make the program more accessible to students with color vision deficiencies. The first step is to determine how color is used in the library space, describing the use of color as the researcher did in the case study observations. Using Cole's three categories of the purpose of color (Cole, 2007), is color being used to send a message or give information (connotative), symbolize something (denotative), or for decoration (aesthetic)? If the purpose of the color is connotative or denotative, students who cannot determine the color may be missing the information. The librarian can make a simple change by using some other way of giving the information. For example, a book's reading level could be written on the colored spine label or the color name could be included on each marker or crayon. When reading a story out loud, the librarian could be sure to give information about the pictures or ask students guiding questions about the pictures. These changes would not only help the students with color vision deficiencies, but would also provide added information for all students. The color name on each marker would help teach students to spell the color words or to identify the letters that make up the color words. A discussion about the pictures in a picture book would help students with other vision impairments or those sitting in the back of the room "see" what is going on in the

pictures. Many of the librarians in the case study did this as a natural storytelling process. As stated earlier, setting up the instruction and the space to be accessible to all as modeled in UDL opens up the accessibility of the information and provides a welcoming environment in the library.

Suggestions for further research

The researcher suggests further studies related what information is provided to school resource teachers about the special needs of students. Resource teachers work with all of the students, often for multiple years, and the comments from the case study participants suggest the resource teachers are not always made aware of the needs of students. Further research could be related to the policies that guide decisions about how information about student needs is disseminated to educators within a school and how these policies are interpreted. As seen in the case study, there is discrepancy among schools within one school division, leaving the researcher to wonder if the policies are interpreted consistently in other schools.

This study could be conducted with other educators, not just with elementary school librarians. Is there a difference in the knowledge and attitudes of educators, depending on the subject or grade level taught? The current study used examples in the instruments that were specific to elementary school libraries, but the concepts would still apply to other educators and the examples could be modified to fit a variety of roles within the school. As one librarian replied on the questionnaire, "My husband has a color deficiency, and many teachers are not aware of how difficult it can make learning especially with more technology and using color as a big part of their classroom and teaching aids." Future research could also focus on how educators design their lessons to

meet the needs of a variety of learners, specifically using the model of Universal Design for Learning.

It would be interesting to conduct a similar study about educators' knowledge and attitudes of color vision deficiencies within a state in which color vision screening is mandated, unlike Virginia. Are educators in other states more aware of the condition, or is more training provided in states where color vision screening is mandated?

Building awareness of color vision deficiencies could begin at the pre-service level. In conversations with other educators in teacher preparation programs including school library, general education, and special education programs, the researcher has not come across anyone who teaches about color vision deficiencies and the needs of the students with the condition. In this study, most participants indicated they did not think the topic was covered in education classes. Another topic for future research would be to determine if color vision deficiencies are discussed in teacher preparation and to study the effect of awareness training on pre-service teachers. It would be interesting to see if new teachers who were provided background knowledge about color vision deficiencies during their pre-service education use color differently in their own classrooms. It would make sense to include this information when discussing the needs of students with all students in teacher preparation programs, possibly in the context of special education or differentiated instruction. A content review could be conducted to determine if color vision deficiencies are covered in popular teacher preparation textbooks related to special needs of students or differentiation.

Finally, the researcher is interested in following up with the case study participants during the new school year to determine if any changes have been made to

library signage, the physical space, or library instruction based on participation in the study.

As mentioned in the introductory chapters, the impact of color vision deficiencies in the educational setting is one that has not been explored in detail. Plenty of medical research can be found related to color vision, including studies on primates and other animals, but little was found related to any connection between color vision deficiency and learning. However, there does seem to be a growing interest in color vision deficiency and the need to increase awareness of this issue. Waggoner, a researcher in the field, wrote the forward for a picture book about color vision deficiencies titled *Just Like Grandpa.* Waggoner and his son have developed a website that gives suggestions to teachers about the needs of students with color vision deficiencies. A new picture book, *Erik the Red Sees Green: A Story about Color Blindness,* has recently been advertised and is set to be published in September 2013. A mother in England began a non-profit called *Color Blind Awareness* (Color Blind Awareness, 2013) with a goal to raise awareness of color vision deficiencies. All profits from the organization go to provide free color vision testing and educational supplies to children with color vision deficiencies. The website is full of useful information and links to articles about the condition, as well as a link to the organization's Facebook page.

As one questionnaire respondent stated, "It is something that needs to be recognized. However, it is disregarded, as you don't hear much about the deficiency. If more people come forward, perhaps those 'voices' can be heard and the problem addressed."

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APPENDIX A

QUESTIONNAIRE/PRETEST

To what extent do you agree or disagree with the following statements:					
	SA	**A**	**D**	**SD**	**DNK**
	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Do Not Know**
General Information about color vision deficiencies					
Color vision deficiency means the person sees everything in black and white	4	3	2	1	0
There are careers which require normal color vision	4	3	2	1	0
Color vision deficiencies are inherited conditions	4	3	2	1	0
Color vision deficiencies can be corrected with treatment	4	3	2	1	0
All people with color vision deficiencies see colors in the same way	4	3	2	1	0
Color vision deficiencies are more prevalent in males than in females	4	3	2	1	0
Pure primary colors are usually distinguishable by people with color deficiencies	4	3	2	1	0
Color vision deficiencies affect a very small percentage of the population in a school	4	3	2	1	0
Background color may make it difficult for some students to read the words on a page	4	3	2	1	0
The name of a color (blue, green, etc.) means the same thing to all people	4	3	2	1	0
In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	4	3	2	1	0
Lighting can affect a person's ability to distinguish between colors	4	3	2	1	0
Color vision deficiencies are discussed in Education courses in college	4	3	2	1	0
Color-coding is a helpful way to categorize information	4	3	2	1	0
Training about color vision deficiencies would be helpful for educators	4	3	2	1	0
People with color vision deficiencies	4	3	2	1	0

know they see the world differently than others	4	3	2	1	0
learn to compensate on their own	4	3	2	1	0
should have a 504 or IEP	4	3	2	1	0
I have thought about the needs of color vision deficient students before this survey	4	3	2	1	0
I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	4	3	2	1	0
Children with color vision deficiencies should be guided to interests in which color discrimination is not important	4	3	2	1	0
The inability to identify colors may be due to carelessness, not color vision deficiencies	4	3	2	1	0
If a child cannot identify colors when tested, it may be because he/she did not understand the test	4	3	2	1	0
Teachers know if there are students in their classes with color vision deficiencies	4	3	2	1	0
What additional thoughts do you have about color vision deficiencies?					
Information about your library/instruction					
I refer to color in pictures when reading books to students	4	3	2	1	0
Signage in the library uses high contrast colors (black/white; red/yellow)	4	3	2	1	0
Book levels are indicated by color-coding in my library	4	3	2	1	0
When color-coding, I provide the information in another way as well (shape, design, etc.)	4	3	2	1	0
I consider the needs of students with color vision deficiencies when:	4	3	2	1	0
designing lessons	4	3	2	1	0
decorating the library	4	3	2	1	0
designing Power Point slides	4	3	2	1	0
The library website is visually accessible to all users	4	3	2	1	0
I use instructional materials that have colors which are visually accessible to all students	4	3	2	1	0
Color is a large component of whole group instruction in my library	4	3	2	1	0
Students with color vision deficiencies will ask other students for help in the library if needed	4	3	2	1	0

Adding the color name when color-coding is helpful	4	3	2	1	0
What additional information would you like to add about the use of color in your library?					
	SA	**A**	**MN**	**DN**	**DNK**
	Strongly Affect	**Affect**	**May not Affect**	**Does Not Affect**	**Do Not Know**
To what degree do you think color vision may affect the following:					
Reading a map	4	3	2	1	0
Reading a picture book	4	3	2	1	0
Reading a graph or chart	4	3	2	1	0
Finding a book on the shelf	4	3	2	1	0
Playing a board game	4	3	2	1	0
Completing a puzzle	4	3	2	1	0
Playing a game on the computer	4	3	2	1	0
Following directional signs in the library	4	3	2	1	0
Information about students					
Color vision deficiency is classified as a disability under Special Education guidelines	4	3	2	1	0
If I suspected a student was color vision deficient, I would want to help him/her	4	3	2	1	0
If I suspected a student was color vision deficient, I would know how to help him/her	4	3	2	1	0
Special Education teachers provide accommodations for students with color vision deficiencies	4	3	2	1	0
Students with color vision deficiencies are receiving assistance/support from parents	4	3	2	1	0
Students with color vision deficiencies are receiving assistance/support from teachers	4	3	2	1	0
Students with color vision deficiencies ask for help when needed	4	3	2	1	0
Have you ever been told by someone in the school that a specific student is color blind?	Yes	No			
If so, what position did that person hold? (teacher, special education teacher, nurse, etc.)					
Have you ever been told by a parent that a specific student is color blind?	Yes	No			
Have you ever been told by a student that he/she is color blind?	Yes	No			

Do you know anyone (other than students) with color vision deficiencies?	Yes	No		
Have you ever suspected that a specific student is color blind?	Yes	No		
If so, what did you do?				
What other information would you like to add about your experiences with people with color vision deficiencies?				
Please answer the following demographic information about yourself:				
Have you attended any previous disability training (class, workshop, etc.)?	Yes	No		
Was color vision mentioned?	Yes	No		
Grade levels in your school (Indicate range)				
Type of library schedule (fixed, flexible, combination)				
Years experience as a school library				
Years experience as an educator				
Level of familiarity with Universal Design for Learning	High	Medium	Low	None
Gender	Male	Female		
Do you have color vision deficiencies?	Yes	No		
What teaching certifications/endorsements do you hold?				

APPENDIX B

EMAIL TO STATE LIBRARIANS

Hello, Fellow Virginia Librarians!

I am currently a Doctoral Candidate in the Darden College of Education at Old Dominion University, and I am collecting data for my dissertation study. My study is related to how color is used in the school library, and I would be most appreciative if you would consider completing my questionnaire. It will take approximately 10 minutes to complete, and no identifying information will be connected to your response. More information about the study is provided on the first page of the survey, along with an opportunity for you to agree to participate or not.

Please consider completing this questionnaire so your responses can be included in my study. A bigger response will result in more accurate data for the study. I greatly appreciate your participation, and look forward to sharing the results when the study is complete.

To enter the survey, please click on this link:

https://www.surveymonkey.com/s/Q28RM32

Please note: you will only be able to complete the survey from your computer one time.

I am happy to answer any questions you may have pertaining to this study. You may contact me at:

Karla B. Collins

Doctoral Candidate

APPENDIX C

STATEWIDE SURVEY INFORMED CONSENT

This questionnaire is part of a larger doctoral dissertation study related to school librarians and color vision deficiencies, more commonly known as color-blindness. The purpose of this survey is to determine what elementary school librarians in Virginia know and believe about color vision deficiencies.

Your participation in this study is very important in order to construct an accurate picture of the thoughts of the elementary school librarians in the state. Your responses will help me understand what librarians in Virginia know and believe about color vision deficiencies. I will include data from this survey in my doctoral dissertation about how elementary school librarians address the needs of students with color vision deficiencies in the school library.

While your participation in this survey is voluntary, I would greatly appreciate your participation. The questionnaire should take about 10-15 minutes to complete. Please note, your responses will be kept confidential. Although this questionnaire was sent to your email address, this email will not be connected to your responses. Further, your responses will not be connected to any personally identifying information. There are no direct benefits given to participants in this survey. The aggregated results will be available upon completion of the study. Completion of the electronic questionnaire indicates your consent to participate in the study.

This study has been reviewed by Old Dominion University's Institutional Review Board and is approved as an exempt study (#12-167).

If you have any questions or concerns about this study, please contact me directly or contact the Responsible Project Investigator (RPI) for this study.

Karla Collins
Doctoral Candidate, Old Dominion University

RPI: Dr. Carol A. Doll
Old Dominion University

☐ I agree to participate in this survey. (Clicking this box will take you to the survey)

☐ I do not agree to participate in this survey. (Clicking this box will exit the survey. You will not be able to re-enter the survey from the same computer.)

STATEWIDE SURVEY ELIGIBILITY GUIDELINES

To be eligible for this survey, you must be a school librarian in a public school in Virginia that includes at least one of the grade levels, pre-kindergarten, 1st, 2nd, 3rd, 4th, or 5th grade. For example, you could be in an elementary school, K-5 or in a middle school which includes 5th grade.

- ○ I am in a school that includes at least one grade level specified above.
- ○ My school does not include any grades listed above. OR I am not a school librarian.

APPENDIX D

QUESTIONS, CONSTRUCTS, AND REVERSE CODING

#	Question	Construct	Reverse?
3-1	Color vision deficiency means the person sees everything in black and white	knowledge	y
3-2	There are careers which require normal color vision	knowledge	
3-3	Color vision deficiencies are inherited conditions	knowledge	
3-4	Color vision deficiencies can be corrected with treatment	knowledge	y
3-5	All people with color vision deficiencies see colors in the same way	knowledge	y
3-6	Color vision deficiencies are more prevalent in males than in females	knowledge	
3-7	Pure primary colors are usually distinguishable by people with color deficiencies	knowledge	
3-8	Color vision deficiencies affect a very small percentage of the population in a school	knowledge	y
3-9	Background color may make it difficult for some students to read the words on a page	knowledge	
3-10	The name of a color (blue, green, etc.) means the same thing to all people	knowledge	y
4-1	In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school	knowledge	y
4-2	Lighting can affect a person's ability to distinguish between colors	knowledge	
4-3	Color vision deficiencies are discussed in Education courses in college	attitude	
4-4	Color-coding is a helpful way to categorize information	attitude	
4-5	Training about color vision deficiencies would be helpful for educators	attitude	
4-6	I have thought about the needs of color vision deficient students before this survey	attitude	
4-7	I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see	attitude	
4-8	Children with color vision deficiencies should be guided to interests in which color discrimination is not important	attitude	

4-9	The inability to identify colors may be due to carelessness, not color vision deficiencies	attitude	
4-10	If a child cannot identify colors when tested, it may be because he/she did not understand the test	attitude	
4-11	Teachers know if there are students in their classes with color vision deficiencies	attitude	
5-1	People with color vision deficiencies know they see the world differently than others	attitude	
5-2	People with color vision deficiencies learn to compensate on their own	attitude	
5-3	People with color vision deficiencies should have a 504 or IEP	attitude	
6	What additional thoughts do you have about color vision deficiencies?	knowledge/belief	
7-1	I refer to color in pictures when reading books to students	knowledge	
7-2	Signage in the library uses high contrast colors (black/white; red/yellow)	knowledge	
7-3	Book levels are indicated by color-coding in my library	knowledge	
7-4	When color-coding, I provide the information in another way as well (shape, design, etc.)	knowledge	
7-5	The library website is visually accessible to all users	knowledge	
7-6	I use instructional materials that have colors which are visually accessible to all students	knowledge	
7-7	Color is a large component of whole group instruction in my library	knowledge	
7-8	Students with color vision deficiencies will ask other students for help in the library if needed	attitude	
7-9	Adding the color name when color-coding is helpful	attitude	
8-1	I consider the needs of students with color vision deficiencies when designing lessons	knowledge	
8-2	I consider the needs of students with color vision deficiencies when decorating the library	knowledge	
8-3	I consider the needs of students with color vision deficiencies when designing Power Point slides	knowledge	
9-1	To what degree do you think color vision may affect Reading a map	attitude	

9-2	To what degree do you think color vision may affect Reading a picture book	attitude	
9-3	To what degree do you think color vision may affect Reading a graph or chart	attitude	
9-4	To what degree do you think color vision may affect Finding a book on the shelf	attitude	
9-5	To what degree do you think color vision may affect Playing a board game	attitude	
9-6	To what degree do you think color vision may affect Completing a puzzle	attitude	
9-7	To what degree do you think color vision may affect Playing a game on the computer	attitude	
9-8	To what degree do you think color vision may affect Following directional signs in the library	attitude	
10	What additional information would you like to add about the use of color in your library?	attitude/knowledge	
11-1	Color vision deficiency is classified as a disability under Special Education guidelines	knowledge	y
11-2	If I suspected a student was color vision deficient, I would want to help him/her	attitude	
11-3	If I suspected a student was color vision deficient, I would know how to help him/her	attitude	
11-4	Special Education teachers provide accommodations for students with color vision deficiencies	attitude	
11-5	Students with color vision deficiencies are receiving assistance/support from parents	attitude	
11-6	Students with color vision deficiencies are receiving assistance/support from teachers	attitude	
11-7	Students with color vision deficiencies ask for help when needed	attitude	
12	Have you ever been told by someone in the school that a specific student is color blind?	demographic/knowledge	
12-o	If so, what position did that person hold? (teacher, special education teacher, nurse, etc.)	demographic/knowledge	
13	Have you ever been told by a parent that a specific student is color blind?	demographic/knowledge	
14	Have you ever been told by a student that he/she is color blind?	demographic/knowledge	
15	Do you know anyone (other than students) with color vision deficiencies?	demographic/knowledge	

16	Have you ever suspected that a specific student is color blind?	demographic/knowledge	
16-o	If so, what did you do?	demographic/knowledge	
17	What other information would you like to add about your experiences with people with color vision deficiencies?	demographic	
18	Have you attended any previous disability training (class, workshop, etc.)?	demographic	
18-o	Was color vision mentioned?	demographic	
19	Grade levels in your school (Indicate range)	demographic	
20	Type of library schedule (fixed, flexible, combination)	demographic	
21	Years experience as a school library	demographic	
22	Years experience as an educator	demographic	
23	Level of familiarity with Universal Design for Learning	demographic	
24	Gender	demographic	
25	Do you have color vision deficiencies?	demographic	
26	What teaching certifications/endorsements do you hold?	demographic	

APPENDIX E

CASE STUDY ACTIVITY AND DATA COLLECTION

Activity	Purpose	Quantitative Data	Qualitative Data
Pre-Observation – Library Space	The current use of color in the library space		Pictures, video, written description
Pre-Observation – Class Instruction	How the librarian uses color in teaching a primary grade class		Pictures, audio, written description
Pre-test	Librarians knowledge of and attitude toward CVD	Questionnaire	Questionnaire – open-ended questions
Interview	Further information about knowledge and attitudes; differentiation, accommodations, answer questions that have arisen		Written description, audio
Training Session	Not limited to case study participants	None collected	None collected
Blog prompts	Training follow-up, applying what was learned		Blog responses
Post-Observation – Library Space	Changes in use of color		Pictures, video, written description
Post-Observation – class instruction; informal discussion	Changes in use of color; new ideas		Pictures, audio, written description
Post-test	Librarians knowledge of and attitude toward CVD, after study participation	Questionnaire	Questionnaire – open-ended questions; added questions about their experiences in the study

APPENDIX F

OBSERVATION PROTOCOL AND CHECKLIST

Observation Protocol

In order to maintain consistency among the observations at each library site in the case study, the researcher will follow specific protocol, taking field notes on the Observation Checklist. The checklist will have space to add areas which may be unique to a library site. A rough map will be drawn of each space as well, allowing space for the researcher to add notes about the position of specific uses of color in the library. Photographs will be taken of examples of color within the library space. No students will be photographed during the observations. When possible, samples of items that include color will be collected as artifacts.

Observation Checklist

Site Code:	Observation Date:	Observation Time:
Pre	Post	
Initial Thoughts/Special Circumstances:		
Directional Signage:		

Displays:

Shelving Areas:

Fiction:

Non-fiction:

Picture Books:

Reference:

Other:

Story Area:

Classroom/Table Area:
Computer Stations:

Unique observations for site:

APPENDIX G

POST-TEST FOLLOW-UP QUESTIONS

Please comment about how each component of the training has impacted your actions in the library:

Facts given in the training about Color Vision Deficiencies

Hands-on time to create materials or work together

Responding to the Blog or reading responses from others

Please answer as completely as possible:

In what ways did the training change the way you think about students?

What changes have you made to your instruction since the training?

What changes have you made in your library space since the training?

APPENDIX H

INTERVIEW PROTOCOL

Opening script

For my dissertation study at Old Dominion University, I am designing a research project related to how school librarians meet the needs of learners. The purpose of this study is to discover the extent to which librarians are aware of and make accommodations for the needs of learners with color vision deficiencies, more commonly referred to as "color blindness." The term color vision deficiency refers to people who cannot see the full range of colors for some reason, either genetic or acquired. I am interested in any strategies that librarians may have used or may use currently with these students. I am particularly interested in school libraries for a couple of reasons. 1) Every student in the school uses the library, and the librarian often has the opportunity to work with all students. 2) Color is often used in story time and library decoration or organization. The interview will take less than an hour, and your responses will be kept confidential. Thank you so much for your participation!

I will be taking notes as well, but I want to make sure to get your comments exactly as you say them. Would it be okay if I recorded this interview? Thank you.

Again, thank you for agreeing to talk with me about accommodations in the library, and agreeing to be audio recorded. Is there a pseudonym you would like me to use in the narrative of the study?

Interview Questions

General Questions about the program

1. Describe your library program, such as type of scheduling, how often you see classes, etc.
2. Do you have time to meet or collaborate with classroom teachers? How often?
3. How do you design your library space to be accessible to all students? What are some examples?

Meeting the needs of learners

4. How do you find out about the needs of specific students?
5. When working with students with suspected but undiagnosed learning problems, how do you differentiate your instruction to meet their needs?
6. How do you adapt materials for the needs of learners?
7. How do you encourage learners to learn to adapt for their own needs?

Experiences with color vision deficiencies

8. Describe your understanding of color vision deficiencies.
9. Tell me about any experiences you have had with people outside of the classroom who have color vision deficiencies.
10. Are you aware of any students in your school (presently or in the past) who have been diagnosed with color vision deficiencies or who you suspected might have problems differentiating between colors?
    a. How did you know?
    b. What did you do?
11. Before hearing about this study, had you ever given thought to the needs of learners with color vision deficiencies? If so, in what context?

Specific site-based questions

12. Individual questions stemming from the site observation, related to either the space or the instruction.
13. Is there anything else you would like to add to what we have talked about?

Thank you so much for your participation. If you would like, I would be happy to share a copy of the transcript of this interview with you to make sure I have accurately collected your thoughts and ideas. Also, I want to remind you that your responses will be kept confidential, and I will refer to you by your pseudonym only, and your school will also not be identifies.

If you would like to contact me to add any more information, feel free to contact me. My contact information is on my business card.

APPENDIX I

TRAINING SESSION AGENDA

1. Icebreaker activity: Choose an object in the room. Without saying what it is, describe the object. How would you describe it without using color words?
2. What are color vision deficiencies?
    a. Power point discussion
3. Mastermind game
    a. Show pegs on the screen in normal color. Match the patterns.
    b. Show new patterns in color adjusted. Match the patterns.

BREAK

4. What is Universal Design for Learning?
    a. Background and overview
    b. Designing a UDL lesson. Representation-Expression-Engagement
5. What can we do in the library?
    a. Share some ideas about the library environment– what are some areas of concern?
        i. Break into small groups to brainstorm ways to prepare the library environment to be accessible to students with color vision deficiencies
        ii. Share ideas with the large group and record to send out later as a reminder
    b. Share some ideas about library lessons – what are some areas of concern?
        i. Break into small groups to brainstorm ways to prepare library lessons to be accessible to students with color vision deficiencies
        ii. Share ideas with the large group and record to send out later as a reminder
6. Designing a UDL lesson
    a. In pairs, design a lesson that will meet UDL guidelines, with special emphasis on the use of color. Representation-Expression-Engagement
7. Role – playing –
    a. Use lesson example from one school – *Blue Chameleon*
        i. *How could you use the principles of UDL to make this lesson accessible to everyone?*
    b. You are practicing map skills with your students using a color coded map. How can you ensure all students in the class are able to complete the lesson?

   c. You are collaborating with a science teacher on a lesson about density. The activity requires students to explain what happens when two differently colored liquids are combined.
   d. You are designing an assignment that requires students to categorize fiction and non-fiction titles by color coding. Apply UDL principles to this assignment.
8. What do we do with this information
   a. Brainstorm ideas
9. Introduce the blog and respond to first blog prompt

APPENDIX J

BLOG PROMPTS

Prompt #1

List two things you learned in the session that you did not know before. What is one thing you plan to use in your library?

Prompt #2

Since the training session, what changes (if any) have you made to your library environment and library lessons? If you have not made any changes, why not? What changes (if any) are you planning to make in the future? If you are not planning any changes, why not?

Prompt #3

Describe an instance in the past 2 weeks that has caused you to think back to the training session. Did you react to the situation differently than you would have before the training? If so, how?

Prompt #4

What questions have come up related to color vision deficiencies that have not been answered?

APPENDIX K

LETTER TO PRINCIPALS

Dear Elementary Principal,

As part of the research for my doctoral dissertation, I have been granted permission to conduct a case study within County elementary school libraries (C study #2012-004). My research is related to the use of color in elementary school libraries and how librarians prepare the library environment and instruction to be accessible to students with color vision deficiencies.

In discussion with ----, I have developed a half-day training session which I will present to all elementary school librarians as part of their on-going professional development, regardless of their agreement to participate in the study. In addition to the training, those who choose to participate in the study will also participate in observations and interviews as described in the attached documents.

As a former librarian in C Schools, I have a working and personal connection to most of the elementary librarians in the school division. I will be the only researcher involved in the data collection in the schools. I estimate my time in each school library to be approximately 3 1/2 hours, including the observations and interview. I will strive to ensure my visits have little impact on the day-to-day activities of the library.

The timeline for this study is as follows:

November: Conduct observations, interviews with librarians, and initial survey

December: Conduct training session for all elementary librarians

January: Conduct post observations and post survey

I greatly appreciate your consideration of this study. This is a topic that is unexplored at this time, and one which could have great impact on the accessibility of information and education to a specific population of learners.

In keeping with C policy regarding research studies in the school, please sign the Principal Agreement to Participate if you agree to allow me to conduct the study in your school. I will also secure informed consent agreements from your school librarian before beginning the study.

Thank you for your time and consideration. I look forward to working in your school library.

Sincerely,

Karla B. Collins

Doctoral Candidate

Old Dominion University

APPENDIX L

EMAIL TO RECRUIT PARTICIPANTS

Dear Librarian,

I would like to invite you to participate in a study I am conducting at Old Dominion University as part of my dissertation research. If you choose to participate, you will be included in a case study related to how elementary school librarians use color and prepare the library environment and instruction to meet the needs of a special group of learners. The following activities will be included in this study:

- Two observations of your library environment and an instructional lesson with a primary classroom
- Individual interview with you, conducted by the researcher (Karla Collins)
- A half-day training session related to the special needs of learners, including a series of blog prompts as follow-up
- A pre-test and post-test related to the topic of the study.

The half-day training session will be provided to all elementary librarians in the school division as part of the on-going professional development activities, regardless of your participation in the case study. If you choose to participate in the study, you will take part in the three additional activities listed above besides the training which will be provided to everyone. I plan to complete the study during the first semester of this school year.

I will contact you in person within the next week to give you more details about the study and to find out if you are interested in participating. Please remember, your participation in the study is completely voluntary; if you choose to participate, you may choose to leave the study at any time.

I look forward to talking to you soon about this study.

Sincerely,
Karla Collins
PhD Candidate
Old Dominion University

APPENDIX M

LETTER TO PARENTS

Dear Parents,

I am a doctoral candidate at Old Dominion University, and I am conducting my doctoral dissertation research in your child's school library. My research is related to the use of color in the school library, and how the librarian develops the library program and services to meet the needs of certain students. The purpose of this letter is to inform you of audio recording that may take place while your child is in the school library.

Part of my research includes observations of instruction within the school library. Your child may be in a class during which time I will be observing the school librarian. During this observation, I will be using audio recording technology to capture the words of the school librarian. After the observation, I will be transcribing the instructional time and only writing down the words of the school librarian. While some student talking may be captured on the audio recording, **no student conversation will be included in the written transcription.** There will be no video recording during this observation. **No students will be identified, by name, image, or other identifying description during this study**. The librarian and the library space are the foci of this study.

This research project has been approved by Old Dominion University's Institutional Review Board as an exempt research project (#12-167). Additionally, County School administration has approved this research project.

If you do **not** want your child in a class that includes an audio recording of the instruction, please fill out and return the form at the bottom of this page to your child's teacher.

I would be happy to talk to you and give you more information about my study, if you are interested. Please contact me directly with any questions, or contact the Responsible Project Investigator, Dr. Carol A. Doll.

Thank you!

Karla B. Collins, Doctoral Candidate
Old Dominion University

Dr. Carol A. Doll, RPI
Old Dominion University

___ I do not want my child to participate a class that will be audio recorded in the library as part of this research project.

Child's Teacher _____ Parent Signature _____

APPENDIX N

INFORMED CONSENT DOCUMENT
OLD DOMINION UNIVERSITY

PROJECT TITLE: Addressing the Needs of Students with Color Vision Deficiencies in the Elementary School Library: Part 2

INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES.
Title of Project: Addressing the Needs of Students with Color Vision Deficiencies in the Elementary School Library: A Case Study
Location: County Schools

RESEARCHERS

Responsible Project Investigator:
Dr. Carol A. Doll, Professor-Library Science Program
Darden College of Education, Department of Teaching and Learning
Investigator:
Karla B. Collins, Doctoral Candidate
Darden College of Education, Department of Teaching and Learning

DESCRIPTION OF RESEARCH STUDY

This case study is part of a doctoral dissertation study related to school librarians and color vision deficiencies, more commonly known as color-blindness. The purpose of this study is to determine what elementary school librarians know and believe about color vision deficiencies and to explore the effect of color vision deficiency awareness training on the behaviors, knowledge, and attitudes of elementary librarians.

If you decide to participate, you will join a case study designed to collect information to form an accurate picture of the thoughts and practices of elementary school librarians. The study will consist of the following elements:

* A pre-test and post-test questionnaire
* Two observations in your school library
* One face-to-face interview session
* A half-day training session (part of the school division's professional development) given to all elementary librarians regardless of study participation, which includes four blog prompts as follow-up to the training.

If you say YES, your participation will take approximately 3 1/2 hours, including the observations and interviews, plus the half-day training session. These activities will take place in your library and in a central meeting location within the school division. Approximately 9 people will be participating in this case study.

Please note: your responses will be kept confidential. You will be assigned a code that will be used in all references to your responses in this study. Your responses will not be connected to any identifying information. The aggregated results will be available upon completion of the study.

EXCLUSIONARY CRITERIA

In order to participate in this study, you should be currently employed by County Schools as an Elementary Librarian.

RISKS AND BENEFITS

RISKS: If you decide to participate in this study, then you may face a risk of personal information being shared by other participants. The researcher will reduce these risks by taking the following measures to protect confidentiality:

* Your school will be given a code which is not related to the name or any other

identifying characteristic of the school. All data will be organized by this code. You will be given a pseudonym that will not be personally identifiable. You will be referred to by the pseudonym in all data reports.

* Identifying information will be removed from the questionnaire responses, observations, and interview transcripts.

And, as with any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS: There are no direct benefits for participating in this study.

COSTS AND PAYMENTS

The researchers want your decision about participating in this study to be absolutely voluntary. Yet they recognize that your participation will require some time commitment. In order to compensate for this, you will be entered into a drawing for a $25 gift card at the end of the study.

NEW INFORMATION

If the researchers find new information during this study that would reasonably change your decision about participating, it will be given to you.

CONFIDENTIALITY

The researchers will take reasonable steps to keep private information, such as questionnaires, observations, and interviews confidential. The researcher will remove all identifiers from the information and securely store information in a locked cabinet or password protected computer until it has been processed. The results of this study may be used in the dissertation, reports, presentations, and publications; but the researcher will not identify you. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE

It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study -- at any time.

COMPENSATION FOR ILLNESS AND INJURY

If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in any research project, you may contact Carol Doll, RPI; Karla Collins, Investigator; Dr. George Maihafer the current IRB chair at Old Dominion University, or the Old Dominion University Office of Research who will be glad to review the matter with you.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Carol Doll, RPI; Karla Collins, Investigator.

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. George Maihafer, the current IRB chair, or the Old Dominion University Office of Research.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

APPENDIX O

UDL BRAINSTORMING GUIDE

Principle	Current Practice	UDL Strategy
Representation		
Representation		
Representation		
Expression		
Expression		
Expression		
Engagement		
Engagement		
Engagement		

APPENDIX P

HELPFUL RESOURCES FOR MORE INFORMATION

Universal Design for Learning

Articles to read:

Creamer, D. (2007). Universal instructional design for libraries. Colorado Libraries, 33(4), 12-15.

Gavigan, K., & Kurtts, S. (2009). AT, UD, and Thee: Using assistive technology and universal design for learning in 21st century media centers. *Library Media Connection*, *27*(4), 54-56.

King-Sears, M. (2009). Universal design for learning: Technology and pedagogy. *Learning Disability Quarterly*, *32*(4), 199-201.

Knowledge Quest, Jan/Feb 2011: "Everyone's special: Equal opportunities for all students to learn."

The entire edition is dedicated to articles about meeting the needs of diverse learners.

Websites to visit:

http://www.udluniverse.com/

This site gives a huge amount of information and resources related to UDL, including reviews of research studies related to UDL.

http://cast.org/index.html

The major research and development organization for UDL. This is the organization that developed the idea.

http://udlonline.cast.org/home

Online learning modules through which you can explore UDL and learn more about how to use the UDL principles in your teaching.

Color Vision

Websites to visit:

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

This link takes you to an article about color vision deficiencies on the WebAIM site. The site is filled with information on how you can design online resources that are user-friendly for a wide range of concerns, including visual, auditory, etc.

http://www.idea.org/blog/2009/05/18/simulating-vision-problems/

Blog with interactive pictures that simulate a variety of color vision deficiencies.

http://www.vischeck.com/

This site allows you to upload images or weblinks to get an idea of what they would look like to people with color vision deficiencies. Also includes a program that will "correct" the color for those with color vision deficiencies.

http://colorvisiontesting.com/

Very helpful basic information about color vision deficiencies, including suggestions for teachers and parents. Designed by Dr. Terrace Waggoner.

http://www.neitzvision.com/content/home.html

This website is created by Dr. Jay Neitz and Dr. Maureen Neitz, two of the most well-known researchers in the world of color vision. They are both professors in the Department of Ophthalmology at University of Washington. Although most of their information is medical in nature, you can be assured it is accurate.

APPENDIX Q

CASE #1: ANGELA

The library at Washington Elementary was a large, open space. The signage in the library was colorful and used high contrasting colors.

In addition to high contrast, there were alternative ways of presenting information, which is also helpful to students with color vision deficiencies. On the walls were large, dark red and dark blue letters to designate the various sections of the library. There were some labels on the book spines that indicated special topics, such as holidays, and the labels all had words and pictures to designate the meaning. All picture books had a red spine sticker but also had large letters on the spine designating the author, as shown in Figure Q1. This was different from the other sections of the library which had regular spine labels.

Figure Q1

Spine Labels on Picture Books

The reference books had a yellow spine label but also had the letters REF as an additional designation. Angela mentioned in the post-test open response items that one change she had made was "making sure not to just refer to things by color alone." In the blog post,

Angela mentioned, "I intend to make sure that any new signage has high contrast colors. Also, graphic representation in addition to letters would also be helpful." In the post-observation, Angela addressed this with the researcher and mentioned that she needed to make new shelf labels for some shelves but did not have any white label tape. She and her assistant discussed whether there would be enough contrast if they used a different color of tape and decided on yellow tape with black letters to keep high contrast.

The story area had a large, colorful rug with many colored squares and alphabet letters. While the color in the rug is mainly aesthetic, Angela did use the color denotatively by telling the students the color of the square on which to sit.

The pre-observation and post-observation were coded for how the librarian used color and presented information about images or pictures to the students. The researcher did not find a change in Angela's behaviors in these areas from pretest to post-test. The results are shown in Table Q1.

Table Q1

Angela - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pretest occurrences	Post-test occurrences
Reference to color	7	8
Descriptions of images or pictures	26	21
Questions about the images or pictures	12	9

In both the pre and post observations, Angela made reference to color multiple times, always in a manner that described something, such as "you can be on the yellow book," when she pointed to a spot on the story carpet. As she read the stories to the classes, Angela described the pictures on almost every page, pointing to certain parts of the book to draw the students' attention to it. Her phrases were very descriptive,

sometime using color words. For example, when she was showing a picture of a coyote to prepare for the story *There was a Coyote who Swallowed a Flea,* she described the picture of the coyote and pointed to the features: "Their fur is light yellowish grey or brownish yellow, and they can have black tips on their fur."

In addition to her many descriptions of images, Angela asked the students questions about the pictures in the stories. For example, in a story about a boy who can't wait for summer, Angela said, "Look at what Matthew S is doing. What does he have on? What is he thinking about for summer?" After the student responses, she affirms their responses and gives more description, saying, "Yep! He wants to snorkel or go swimming. He has fins on and a mask and all of that, so he's thinking about summertime!"

In the interview with Angela, she stated that she had "very little understanding" of color vision deficiencies and that anything she learned throughout the course of the study would "probably be completely new to me." She indicated on the pretest that she did not know anyone with color vision deficiencies and had never known of a student with this issue.

In the pretest, Angela's average score for the knowledge items was 2.79. This changed to 3.39 in the post-test. This could be attributed to the amount of items that for which her response changed from a level of disagreement to a level of agreement. Some of the greatest changes in knowledge scores on individual items for Angela are shown in Table Q2.

Table Q2

Angela - Change Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
0 to a number (1-4): • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • The library website is visually accessible to all users • I use instructional materials that have colors which are visually accessible to all students • Color vision deficiency is classified as a disability under Special Education guidelines
Disagree/strongly disagree to agree/ strongly agree: • Signage in the library uses high contrast colors (black/white; red/yellow) • When color-coding, I provide the information in another way as well (shape, design, etc.) • I consider the needs of students with color vision deficiencies when designing lessons • I consider the needs of students with color vision deficiencies when decorating the library • I consider the needs of students with color vision deficiencies when designing Power Point slides
Agree/strongly agree to disagree/strongly disagree: • Book levels are indicated by color-coding in my library

Angela responded *do not know* on four of the items in the knowledge scale, including Item 4-1r, "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school." In the interview, Angela stated "I presume they test for it when they do the vision screening, but I don't know that that's necessarily true." In the post-test, Angela "strongly disagreed" with this same item, indicating a change in her knowledge. She also mentioned this in the open response items, saying, "The test should be required as part of school vision screening."

Another knowledge item for which Angela showed a large change, from *do not know* to "strongly disagree" was Item 11-1r, "Color vision deficiency is classified as a

disability under Special Education guidelines." Angela chose the zero score for two other items in the pretest, which both changed in the post-test to "agree" or "strongly agree." These items, 7-5 and 7-6, were related to color in the library website and color in instructional materials.

It is interesting to note that Angela changed from disagreeing to agreeing on all of the items that were related to her consideration of the needs of students with color vision deficiencies. Angela referred to this change multiple times in the post-test open response items, the blog posts, and the interview when she said she had an increased awareness of the needs of students with color vision deficiencies.

For the attitude scale, Angela's scores averaged to 2.80 on the pretest and 2.52 on the post-test, showing a decrease in score. Her responses on items that showed a great change are shown in Table Q3.

Table Q3

Angela - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4): • Students with color vision deficiencies are receiving assistance/support from teachers • Color vision deficiencies are discussed in Education courses in college • People with color vision deficiencies know they see the world differently than others • People with color vision deficiencies learn to compensate on their own • People with color vision deficiencies should have a 504 or IEP • Students with color vision deficiencies will ask other students for help in the library if needed • Students with color vision deficiencies are receiving assistance/support from parents • Students with color vision deficiencies ask for help when needed
A number (1-4) to 0: • Color-coding is a helpful way to categorize information • Training about color vision deficiencies would be helpful for educators • If I suspected a student was color vision deficient, I would know how to help him/her
Disagree/strongly disagree to agree/ strongly agree: • I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see • Children with color vision deficiencies should be guided to interests in which color discrimination is not important
Affect/strongly affect to not affect/strongly not affect: • To what degree do you think color vision may affect following directional signs in the library

There were eight items for which Angela chose *do not know* on the pretest. All of those items changed to an agree/disagree scaled score on the post-test. On three of these items, Angela changed from *do not know* to strongly disagreeing, indicating a new strong attitude about those items. The other eight items did not change to the "strong" level. Three of the items which changed from a zero to a score were the items related to the

support the students are receiving from various people. Angela's response on all of these items changed into the disagree/strongly disagree range.

It is interesting to note that Angela changed three items to zero scores on the post-test and that all of these items on the pretest received a "strong" score. One of these items was Item 4-4, "Color-coding is a helpful way to categorize information." Angela addressed her changing attitude in the interview:

> Until you came, I never really thought about it. Now I'm much more aware. We were at another school yesterday, and I'm looking at how she uses color, probably more than I do and I never really thought about it. I thought 'Oh, it's easy. We can color code everything and that will make it easier.' But if you don't see it as that color, it's not so simple.

Later she said, "Saying 'Oh, look at the red sticker' doesn't mean something if somebody doesn't see it as red." More discussion related to changes from a score to *do not know* can be found in chapter five.

APPENDIX R

CASE #2: NAIRE

The library at Jackson Elementary was painted with vibrant colors and filled with natural light from a large panel of windows and a large skylight. To the right of the entrance was the picture book and chapter book area sectioned off from the rest of the library by low bookcases. There were many books on display on top of the shelves. The story area was set up next to the circulation desk in the center of the library. A large projection screen was on the wall and a colorful rug was between the screen and the table area.

There are some examples of contrast and providing information through color but also in other ways. The only directional signs in the library were on top of the bookshelves indicating what books were in that section (fiction, non-fiction, etc.) and used high contrast colors. The reference books had red spine labels and an additional red sticker in the shape of a stop sign with the word "Stop," indicating the book could not be checked out. Various shelves within each section were labeled with white label tape and black letters, for example, "Last name starts with L."

Many of the books in the library were labeled with colored dots and stars of various sizes which could be confusing to students with color vision deficiencies. There were a variety of stickers on the spines of books in this area included a variety of colored dots and stars. The chapter books had lavender colored spine labels in addition to the dots and stars. There was no indication in this area of what the colors meant in the bookshelf areas, but there was a poster over the circulation desk in the middle of the library that

showed which colors represented various reading levels. On the other side of the library, the non-fiction books had similar dots and stars but had blue spine labels.

The pre-observation and post-observation were coded for how Naire used color and presented information about images or pictures to the students. The results of the coded observations are shown in Table R1.

Table R1

Naire - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	6	19
Descriptions of images or pictures	1	1
Questions about the images or pictures	4	18

Naire's use of color references increased greatly from pre-observation to post-observation. The post-observation consisted of many activities that all revolved around color. The lesson began with a discussion of colors that are related to Valentine's Day. Then Naire showed some colors from a book on the projection screen, named the color for the students, and asked them for things that they knew of which were that color. Naire asked the students many more questions about the pictures in the post-observation lesson, and many of the questions were related to colors, such as, "This is a purple what? Can you think of objects that have the color purple?" Other questions were asked during the next part of the lesson when Naire created a graph of the students' favorite colors using a computer program shown on the projection screen. In both observations, Naire made multiple references to the images from the books not showing clearly on the screen. In the post-observation she told the students, "Guys, when we project colors on the

document camera, they don't always show their true colors." When projecting a picture of things that were purple, Naire said, "It doesn't look purple to me on the screen. It looks blue, doesn't it?" Although Naire commented throughout the observation that the colors did not show correctly on the screen, she did not make a change to show the book directly to the students instead of using the document camera.

When asked in the interview about her knowledge of color vision deficiencies, Naire described her own vision problems and said because of the issues she has faced, she is more sensitive of the needs of others. She described color vision deficiencies as, "It's when student aren't seeing the same colors that are normally," and stated she had never known about a student with color vision deficiencies. She described her use of colors in the library: "Looking around the library before your study, I always thought that, you know, using color coded for reading labels, using stickers, and for color coded areas to distinguish would be helpful."

Naire's scores on the knowledge scale increased slightly from pretest ($\mu = 2.70$) to post-test ($\mu = 2.91$). The individual items with the greatest changes are shown in Table R2.

Table R2

Naire - Change in Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
A number (1-4) to 0:
• Signage in the library uses high contrast colors (black/white; red/yellow)
Disagree/strongly disagree to agree/ strongly agree:
• Color vision deficiencies are more prevalent in males than in females
Agree/strongly agree to disagree/strongly disagree:
• Color vision deficiencies can be corrected with treatment
• In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school
• Color vision deficiency is classified as a disability under Special Education

guidelines

Many of the items in the knowledge scale remained the same from pretest to post-test for Naire. However, the items highlighted in the table above were those with the greatest change. One item about the signage in the library, changed from Naire agreeing that the signage was high contrast on the pretest to her choosing *do not know* in the post-test. When talking about the color coding in the library during the interview, Naire commented, "I didn't have any rhyme or reason why I was doing this. But your study made me think, 'Oh, I do use color!'"

The other four items recorded in the table are all items related to general knowledge about color vision deficiencies. For each of these items, Naire's responses changed from incorrect knowledge on the pretest to accurate information on the post-test.

On the attitude scale, there were few changes on the individual items in Naire's responses from pretest ($\mu = 2.73$) to post-test ($\mu = 2.61$). The two items with the greatest change are shown in Table R3.

Table R3

Naire - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
Not affect/strongly not affect to affect/ strongly affect:
• To what degree do you think color vision may affect finding a book on the shelf
Agree/strongly agree to disagree/strongly disagree:
• I have thought about the needs of color vision deficient students before this survey

It is interesting to note that only one item in the set about the affect of color vision deficiencies on various library tasks had a change in agreement. This was Item 9-4, "To

what degree do you think color vision may affect finding a book on the shelf" In Naire's library, color is used to identify book levels, as was noted in the library space observation. Naire described the color coding system in great detail in the interview, showing the color chart to the researcher as she explained the system: "Now if you're in first grade then you should choose a purple dot...Now second grade red..." and so on through the levels. An image of the color chart was used in the training session with Naire's permission and is included in chapter five.

Another interesting change in the pretest and post-test results for Naire was the change in Item 4-6, "I have thought about the needs of color vision deficient students before this survey," from "agree" to "disagree." In the interview she addressed this a couple of times such as when she said, "It makes you more aware of why you do something, or think about why you use color or how you use color. Because to me, I just don't think about it. It's just a thing you did, you know?"

A change of behavior was evident in the post-observation of Naire's library instruction. Since her lesson revolved around color, it was easy to see how she was using the information that had been presented in the training. When Naire was showing pictures colors, she showed the image, named the color, and asked the students to name items that were that color. The picture on the screen of multiple items of that color provided visual clues for those who might need the scaffolding, and no students were called on without volunteering. For example, she showed a picture of blue items on a blue page, and asked, "Can you think of a fruit that is the color blue?" When quizzing the students on shapes, Naire showed the picture and again gave the color, asking the students to name the shape, "This is a purple...what shape?"

APPENDIX S

CASE #3: THELMA

The library at Roosevelt Elementary had plenty of natural light with a wall of windows around one side of the main library and a large skylight near the entrance to the picture book/story area.

There are many examples of high contrast in the library, which are visually friendly to students with color vision deficiencies. The directional signs are yellow with black lettering and include brightly colored images. In the non-fiction section, there are white labels with black lettering on the shelves giving the Dewey Decimal numbers. There are some books with colored subject labels, and the labels also include images and words to define the subject. The reference books have a yellow sticker on the spine with a large "R" on the sticker. While the yellow sticker does give the information about the type of book, the large letter provides the same information in a different way, and the color contrast is strong.

Color is used connotatively in the use of colored spine labels to indicate book level. Some of the chapter books and picture books have colored dots on the spines with no other indication of the meaning of the color. In the interview, Thelma indicated that Roosevelt Elementary formerly used Accelerated Reader but does not anymore. She has not removed the stickers from the books that indicated the Accelerated Reader book level.

The researcher coded the pre-observation and post-observation for any references to color and how the librarian described images and questioned students about images. The results are shown in Table S1.

Table S1

Thelma - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	1	3
Descriptions of images or pictures	0	14
Questions about the images or pictures	0	12

Due to scheduling difficulties, the pre-observation of Thelma's lesson was an observation of a first grade class. There was no story time on this day. This particular class started the lesson by taking short quiz about the difference between fiction and non-fiction. Thelma read the questions to the class and they wrote if the item was fiction or non-fiction. Interestingly, the first item in the quiz was the one reference to color in this lesson, "Leaves turn green in the fall." After the quiz, each student was given a set of books to sort into fiction and non-fiction. While she talked to the students individually about their books, Thelma did not reference color or describe any of the pictures to any students during the rest of the observation. The only question about pictures was when Thelma was talking to one student about the fiction books, and she asked the student, "Does it have talking animals in it?"

The post-observation took place during a kindergarten class that included a story time. However, in this observation, the three references to color all came after the story when the students were coloring pictures and Thelma was talking to them individually. All of the references were about colors the students used in their pictures such as "I like those bright yellow pants. You can see him coming down the street!"

As Thelma read the two stories to the class in this lesson, she described the pictures on many of the pages, pointing to images in the pictures to draw students' attention to what she was describing. In the story *Meerkat Mail,* Thelma pointed out, "Look who is sneaking onto the page. That jackal is coming back? He does look like a fox, but he's a jackal." She also asked many questions about the pictures during the stories, encouraging students to think about what they saw in the pictures. For example, when showing the cover of one book, *Millie Waits for the Mail,* Thelma asked, "Who do you think Millie is by looking at the cover?" When students responded, she probed further with, "Is there anyone else it could be? Who could it be? You think the cow, but is there anyone else?"

Thelma's score increased from pretest ($\mu = 2.72$) to post-test ($\mu = 3.18$) on the overall knowledge scale. In the interview, Thelma shared her experiences with a close friend in college who had multiple vision problems including color vision deficiencies. Although she had prior experiences with people with color vision deficiencies, her results on the knowledge scale still showed an increase in knowledge from pretest to post-test. The individual knowledge items with the greatest changes are shown in Table S2.

Table S2

Thelma - Change in Scores from Pretest to Post-Test, Knowledge Items

Knowledge Items that changed from
0 to a number (1-4): • Color vision deficiencies can be corrected with treatment • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • The library website is visually accessible to all users • I use instructional materials that have colors which are visually accessible to all students • Color vision deficiency is classified as a disability under Special Education guidelines
A number (1-4) to 0: • When color-coding, I provide the information in another way as well (shape, design, etc.)
Disagree/strongly disagree to agree/ strongly agree: • I refer to color in pictures when reading books to students • I consider the needs of students with color vision deficiencies when designing lessons • I consider the needs of students with color vision deficiencies when decorating the library • I consider the needs of students with color vision deficiencies when designing Power Point slides

There were five knowledge items which Thelma initially chose *do not know* then changed to agreement in the post-test, showing a change in knowledge in these areas. Three of these items were related to general knowledge about color vision deficiencies and two were related to knowledge of the use of color in her library space or instruction. In the post-test open response items, Thelma mentioned this, saying, "I was aware of color issues, but now I think about it more."

Thelma changed one item related to her use of color coding, from strong disagreement to *do not know.* One example of a way she has changed her use of color was, "I have used different colored markers to see if there were any changes in student responses."

There were four items which changed from disagreement in the pretest to agreement in the post-test, suggesting a growth in knowledge. Three of these items were the set of items about the degree to which the needs of students with color vision deficiencies are considered when designing the library space and instruction. Although Thelma stated in the post-test that she felt her space was well designed, she also said that she has learned to "be careful about contrasts and don't assume a student can see colors."

Thelma's score increased slightly for the attitude items from pretest ($\mu = 2.39$) to post-test ($\mu = 2.67$). The individual items within the attitude scale with the greatest change are noted in Table S3.

Table S3

Thelma - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4): • Students with color vision deficiencies will ask other students for help in the library if needed
Disagree/strongly disagree to agree/ strongly agree: • I have thought about the needs of color vision deficient students before this survey • Children with color vision deficiencies should be guided to interests in which color discrimination is not important • The inability to identify colors may be due to carelessness, not color vision deficiencies • People with color vision deficiencies learn to compensate on their own • To what degree do you think color vision may affect reading a picture book • If I suspected a student was color vision deficient, I would know how to help him/her

While Thelma marked *do not know* for five items in the pretest, four of the five remained as zero in the post-test. The one that changed was Item 7-8, "Students with

color vision deficiencies will ask other students for help in the library if needed." This item changed to "disagree" in the post-test.

There were six items which Thelma changed from "disagree" in the pretest to "agree" in the post-test. She addressed her attitude about students learning to compensate in the interview when she talked about a college friend with color vision deficiencies who memorized the order of the lights on a stoplight and always wore jeans with either white or black t-shirts. She said, "People do come up with ways of adapting." It is interesting to note that Item 11-3, "If I suspected a student was color vision deficient, I would know how to help him/her," was one item which she showed a change to agreement after the training session. She further stated on the post-test, "It would be helpful to know if a child has color vision deficiencies just like it is helpful to know about other vision issues."

APPENDIX T

CASE #4: EMILY

The library at Coolidge Elementary School is a long, narrow space that seems very dark. The library is an interior room with no windows to the outside, so there is very little natural light. The fiction books (chapter books and picture books) are on the right side of the room, and the non-fiction books are along the left wall. The story area is in the far back corner of the library. It is a small space with risers for the students to sit when hearing a story. Emily has a rocking chair at the entrance to the story area with a white board beside the chair. There is a low shelf with board books on the side of the story area. During the observations, students were allowed to look at these books while waiting for the teacher to pick them up at the end of the lesson.

Much of the color used in the library provides strong contrast which is helpful to students with color vision deficiencies. Large silver letters on the dark walls provide direction to various sections of the library. Some shelves have white labels with black lettering giving the subject and Dewey Decimal number or author's initials. There are also small pictures of sample books for that section on some of the fiction shelves. Accelerated Reader books have a dark blue spine label that has "Accelerated Reader" written in white letters. Some of the reference books have a white label with "REF" in red lettering on a label at the top of the spine. Some have the REF prefix at the beginning of the call number.

Some connotative uses of color are seen in the library space. There are some books that have small colored (green, blue, or red) dots on the spine with no indication of

the purpose of the color. Emily stated later that all "easy readers" are shelved together and marked with the blue dot.

The pre-observation and post-observation were coded for any references to color and how the librarian described pictures and asked questions about pictures. The results of the two very different lessons are shown in Table T1.

Table T1

Emily - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	30	0
Descriptions of images or pictures	5	6
Questions about the images or pictures	6	0

In the first lesson observation, Emily read a story to the class called *Blue Chameleon* in which a chameleon changes colors based on its emotions. To lead up to this lesson, Emily talked at length to the students about the phrase "feeling blue." She then read the story twice to the class, the second time having the students act out the body poses of the chameleon in the pictures. She followed the story with an activity where the students walked to part of the library marked with a color to show how an emotion made them feel. For example, "Walk to the color you feel when you are sad." To lead into this activity, Emily walked to each color, pointed to the paper, and told the students the color name. With Emily's permission and without giving the name of the school, this activity was described to the group in the training session as an example of providing an accommodation that would benefit those with color vision deficiencies.

Due to the subject of this lesson, Emily made a very large amount of references to color in the pre-observation. She also described what the chameleon was doing in the pictures so the students could mimic the picture, and asked a lot of questions about the pictures. For example, one picture showed just a part of an animal, and Emily asked, "I want you to make a prediction. What do you think this hand or foot might belong to?"

The story Emily read in the post-observation was about a monster under the bed, titled *I Need My Monster.* While she read this story, she did not stop to point out images or ask questions. She was very animated in her reading, using monster voices and sounds that were described in the story like heavy breathing, slurping, and scratching. The follow-up activity had the students draw pictures of monsters for each other. They had to describe a monster from their minds for the other student to draw. Emily referred to color a few times when she demonstrated the activity, telling the students the color she was using on the white board, a suggestion given in the training session, but she did not ask any questions about pictures or describe pictures to the class in this lesson. This is a deviation from the pre-observation story time but may have been due to the nature of the story.

In the interview, Emily stated that she had never been told that a student had color vision deficiencies and did not know anyone personally with this issue. While she described her level of understanding as "not too great," she was able to give some accurate basic information about color vision deficiencies such as it affects more males than females and that the most common deficiency is red-green. She said she had attended training about using a Smart Board, and in that training the importance of high contrast was mentioned but not in reference to color vision specifically. Emily gave many

examples of ways in which she differentiates lessons to meet the needs of students in her school. She said, "What I'll try to do is include components of every lesson to hit as many different types of learners as I can." This was evident in the many activities that were part of both lesson observations for this study.

Emily's scores increased slightly on the knowledge scale from pretest ($\mu = 2.89$) to the post-test ($\mu = 3.10$). The greatest changes were on the items shown in Table T2.

Table T2

Emily - Change in Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
0 to a number (1-4): • Color vision deficiencies can be corrected with treatment • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • The library website is visually accessible to all users • I use instructional materials that have colors which are visually accessible to all students • Color vision deficiency is classified as a disability under Special Education guidelines
A number (1-4) to 0: • Color vision deficiencies affect a very small percentage of the population in a school • When color-coding, I provide the information in another way as well (shape, design, etc.)
Disagree/strongly disagree to agree/ strongly agree: • I consider the needs of students with color vision deficiencies when decorating the library
Agree/strongly agree to disagree/strongly disagree: • Signage in the library uses high contrast colors (black/white; red/yellow)

For all five of the items for which Emily had responded *do not know* in the pretest, she responded with a level of disagreement in the post-test. Since three of the items were reverse coded, disagreement was considered the correct response on those items. These three items were related to general knowledge about color vision

deficiencies. On the post-test Emily added a comment: "I didn't know much about it before. Now I have the facts about percentages, what it really looks like, etc." The two items for which she changed from a zero response to disagreeing were both items related to the accessibility of the website and instructional materials in her library program. In one blog post, Emily wrote, "One thing I plan to use in my library is the website that allows you to check images and web pages to see what they would look like for people with various color deficiencies."

Emily changed to a *do not know* response for two of the post-test items, showing her discomfort with her knowledge of the information. She changed from disagree to agree on the item about considering the needs of students with color vision deficiencies when decorating the library and changed in the opposite direction on the item about the library signage. On one blog prompt, Emily wrote, "I will be working on signage in the future!"

On the attitude scale, Emily's scores increased from pretest ($\mu = 2.71$) to post-test ($\mu = 2.95$). A few individual items showed a change and are presented in Table T3.

Table T3

Emily - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4): • Children with color vision deficiencies should be guided to interests in which color discrimination is not important
A number (1-4) to 0: • If I suspected a student was color vision deficient, I would know how to help him/her
Not affect/strongly not affect to affect/ strongly affect: • To what degree do you think color vision may affect reading a picture book • To what degree do you think color vision may affect finding a book on the shelf

- To what degree do you think color vision may affect Following directional signs in the library

It is interesting to note the items that changed from *do not know* and to *do not know* in Emily's case. Emily showed an attitude decision that students should be guided to interests in which color discrimination is not important. On the other hand, she changed to a zero response for the item about her ability to help a student with color vision deficiencies. She did state on the post-test that the blog responses "helped me reflect on my own personal practice."

On three of the items assessing the degree to which she felt color vision may affect library tasks, Emily changed to a level of agreement. This changed resulted in her indication that all of the tasks listed may be affected or strongly affected by color vision. One change Emily noted in the post-test was that since the training, "I have described things using color plus another adjective."

APPENDIX U

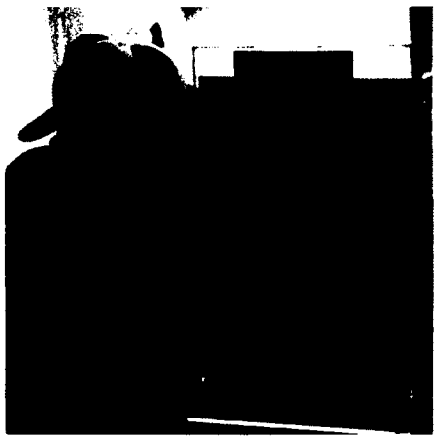
CASE #5: LUCY

The library at Franklin Elementary School is a large, bright, open room with a large wall of windows bringing in plenty of natural light. Bookshelves are scattered throughout the space and there are many colorful displays on top of most of the shelves.

The library space includes some examples of high contrast or alternatives ways of providing the information which are helpful to students with color vision deficiencies. There is very little directional signage in the library other than what is on individual shelves. Throughout subject sections, there are displays of items that show those subjects. For example, there are stuffed animals on display near the animal section. Some books have subject labels on the spine, which are colored and have a small picture as well as the name of the subject. The books in the picture book area have large white labels and the shelves also have white labels with black letters. In the non-fiction section, the spine labels and shelf labels are white with black Dewey numbers. Some shelves have subject word labels as well.

Figure U1

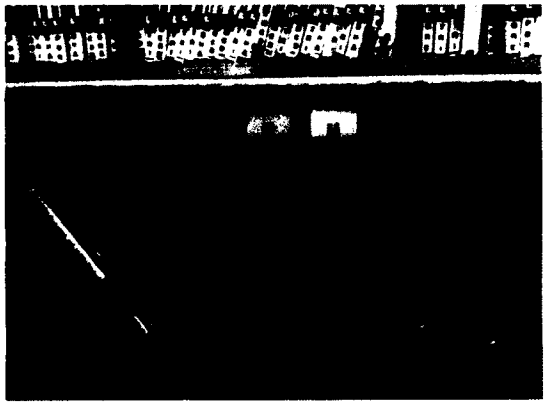
Subject Area Signage with Prop



Some uses of color could cause confusion in students with color vision deficiencies. In the fiction section, large yellow labels on the spines of the books have black letters indicating the author. Although the color combination provides strong contrast, there is no prefix for fiction, just the yellow labels which is a connotative use of color since the color is sending the message of what type of book is on the shelf. Yellow letter squares on the shelves give the author initials for that shelf.

Figure U2

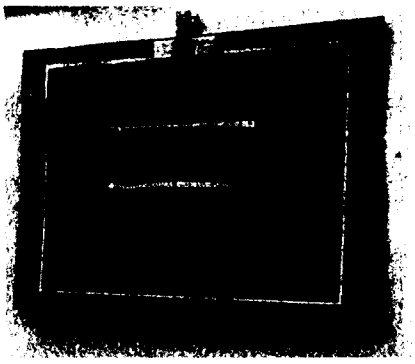
Yellow Shelf and Spine Labels



There are some books with a blue "Accelerated Reader" sticker on the spine, and there are some with the same subject spine labels as are in the fiction section. Graphic novels have green spine labels. The story area is designated with a colorful rug with letters inside colored squares, an aesthetic use of color. One sign was noted in the observation that was printed on a dark background, decreasing the contrast between the informational text and the background color and causing a possible area of confusion for students with color vision deficiencies.

Figure U3

Sign with Low Contrast



The pre-observation and post-observation were both coded to note when Lucy referred to color in her lessons and when she described the pictures or ask questions about the pictures. The results are recorded in Table U1.

Table U1

Lucy - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	21	15
Descriptions of images or pictures	4	1
Questions about the images or pictures	0	1

In both of the observations, Lucy read stories or did activities that included references to color. For example, the pre-observation took place just before Thanksgiving, and Lucy had the students sing a Thanksgiving song and place colored paper feathers on a turkey on the flannel board. This activity required the students to know what color they were holding in order to put their feather on the turkey at the right time in the song. This could have posed problems for students with color vision deficiencies.

Figure U4

Turkey with colored feathers

In the post observation, she shared the story *Pete the Cat: I Love my White Shoes.* This is another story in which many colors are mentioned. These activities accounted for many of the references to color in the lesson observations. Lucy did not describe many of the pictures as she read stories, nor did she question the students about what was happening in the pictures. Most of her questions were predictions or questions to get the students to think deeper about the story. It was difficult to observe any change in the way Lucy presented colors in this lesson since the post-observation did not require the students to make any judgments about color as the pre-observation lesson did.

In the interview, Lucy stated that she had very little knowledge of color vision deficiencies and had never been told about any students with the issue. She talked about an adult acquaintance who made a casual comment about being color blind at one point, but said it was just a passing comment. She stated that color is a large part of what she does with students in the library. "Almost every single story time that I do with the little kids, the kindergarteners, has some sort of color. It's the song or rhyme or the story, whatever. We're constantly doing that."

Lucy's scores on the knowledge scale increased from pretest ($\mu = 2.67$) to post-test ($\mu = 3.19$). There were six items for which Lucy had chosen zero in the pretest and a scale number in the post-test. These items and others with changes in score are shown in Table U2.

Table U2

Lucy - Change in Scores from Pretest to Post-Test, Knowledge Items

Knowledge items that changed from
0 to a number (1-4): • Color vision deficiencies are inherited conditions • Color vision deficiencies can be corrected with treatment • Pure primary colors are usually distinguishable by people with color deficiencies • Color vision deficiencies affect a very small percentage of the population in a school • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • Color vision deficiency is classified as a disability under Special Education guidelines
Disagree/strongly disagree to agree/ strongly agree: • I consider the needs of students with color vision deficiencies when designing Power Point slides • I consider the needs of students with color vision deficiencies when decorating the library • I consider the needs of students with color vision deficiencies when designing lessons
Agree/strongly agree to disagree/strongly disagree: • Signage in the library uses high contrast colors (black/white; red/yellow)

Most of the items which changed from *do not know* to a level of agreement or disagreement were general knowledge about color vision deficiencies, indicating a change in Lucy's knowledge from pretest to post-test. Lucy referred to this in her first blog posting when she said, "I was really surprised at the pervasiveness of color deficiencies in boys. On the three items related to her consideration of the needs of students with color vision deficiencies, Lucy changed from disagree to agree. When the

researcher arrived for the post-observation, Lucy talked about how she had been changing her lessons since the training: "I'm aware that I need to be figuring out how to change my lessons so they are accessible to everybody. So I have that awareness but I don't always know how to go about adapting it." After the lesson, the researcher and Lucy talked about the lesson and that there were no observed instances where color could be confusing to a student in this particular lesson.

One item which changed from agree to disagree was related to the signage in the library. Lucy expressed her desire to change some of her signage in the post-test open response items and in one of her blog posts. She also said she is trying to change the name she calls a book cart, always referring to it as the "purple cart." Since the cart has a smiley face poster on the side, she said in the post-observation, "If we call it 'purple smiley face cart' that is more inclusive." This showed a change in the way Lucy is beginning to think about references to color in the library.

For the attitude scale, Lucy had a slight decrease in score from pretest ($\mu = 2.95$) to post-test ($\mu = 2.59$). However, this is another example of a number of items changing from zero, which was not factored into the scale average, to a scale score. Changes are indicated in Table U3.

Table U3

Lucy - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4): • The inability to identify colors may be due to carelessness, not color vision deficiencies • Teachers know if there are students in their classes with color vision deficiencies • People with color vision deficiencies know they see the world differently than others • People with color vision deficiencies learn to compensate on their own • People with color vision deficiencies should have a 504 or IEP
A number (1-4) to 0: • If a child cannot identify colors when tested, it may be because he/she did not understand the test • Students with color vision deficiencies will ask other students for help in the library if needed • Adding the color name when color-coding is helpful • Students with color vision deficiencies ask for help when needed
Agree/strongly agree to disagree/strongly disagree: • I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see

Of the five items that changed from zero to a scale number, the only one to change to agreement was Item 5-3, "People with color vision deficiencies should have a 504 or IEP." The other four items changed to "disagree" on the post-test. While not shown in this table, it should be noted that the three items that were related to the support received by students with color vision deficiencies remained at a zero for both the pretest and the post-test.

Four items changed from a scale number to a zero on the post-test. This suggests an increasing discomfort with answering these items accurately. It is also interesting that the one item which Lucy changed from agree to disagree was Item 4-7, "I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see." This issue

was addressed in the training session by sharing the video *No Such Thing as Color*, an interview with a man with color vision deficiencies who talks about his experiences through life.

APPENDIX V

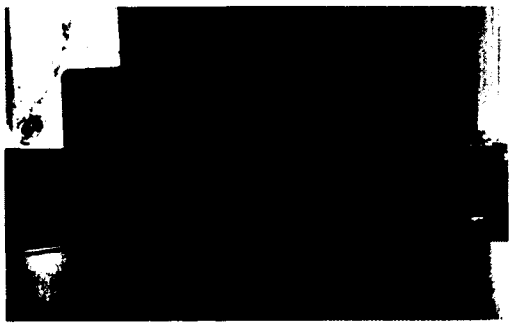
CASE #6: LOTTIE

The library at Carter Elementary School is a bright, small room with painted murals on the walls and a large tree sculpture in the reading area. There are many books and stuffed animals on display on the tops of bookcases, and the bookcases divide the space into various areas such as a small group table, the classroom table area, and a computer area.

Much of the signage in the library uses high contrast colors and further demarcation that are helpful tools for students with color vision deficiencies. The directional signs in the library are dark blue with white letters and are standing on top of the various sections. Reference books have the prefix REF at the top of the Dewey Decimal number on the spine label. There are some colored subject labels on books which also give the subject in words and with a picture, providing alternative ways to determine the meaning of the label.

Figure V1

Signage with High Contrast



Some sections of the library include connotative use of color which could be confusing to those with color vision deficiencies. In the fiction sections (chapter book and picture book), there are colored spine labels on many books, indicating Accelerated Reader levels. The level information is written inside the back cover of each book. In the

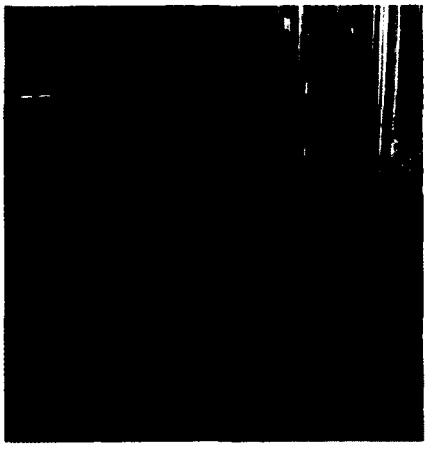
non-fiction section, some books have lavender tape on the spines and the book level written on the tape. Subject labels are the same as those in fiction. Graphic novels have a large G on the spine and colored spine labels indicating the Accelerated Reader level. The dark color of the spine labels decreases the contrast and could make it difficult for students with color vision deficiencies to read the letters on the label. Another area of possible confusion can be seen on some of the posters which use dark backgrounds, such as dark blue, and do not provide a high contrast.

Figure V2

Color Coded Spine Labels

Figure V3

Poster with Low Contrast Areas



During the interview, Lottie said she does not have any past experience with color vision deficiency except for the color test given by her eye doctor. As she explained, "My understanding of it is that we all see colors, but some people who are deficient in that don't see bright colors or any of some colors." She wondered, "Do some people in our school know more than they are telling me? I never knew to ask." She expressed interest in learning about color vision deficiencies, "In the library where there's the openness of going where you want and looking at covers of books and now with this AR and people have color...I want to know more about it!"

Lottie's pre-observation and post-observation were coded for references to color, descriptions of pictures, and questions about pictures. Lottie's post-observation included the students participating in stations and not a story time as was included in the first lesson. The frequency of the coded events in each observation is included in Table V1.

Table V1

Lottie- Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	7	4
Descriptions of images or pictures	7	10
Questions about the images or pictures	3	6

In the pre-observation, most of the references to color were part of the text of the stories, such as "Thank you for fall and gold leaves floating by." Lottie took time during the stories to describe some of the actions in the pictures and to ask guiding questions. Although the second observation did not include a story time, Lottie described pictures more in this observation. The students were working in small groups at stations

throughout the library and Lottie circulated among the stations. Many of the descriptions of pictures occurred at the station where students were categorizing books into fiction and non-fiction and the station where students were playing a matching game. At this station, she modeled how to describe the picture in the game card so the others playing could hear the description. The other stations were: computers, puzzles, drawing, and reading.

Lottie's score for the knowledge scale increased from pretest ($\mu = 2.70$) to post-test ($\mu = 3.18$). The items which changed for Lottie are shown in Table V2.

Table V2

Lottie - Change in Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
0 to a number (1-4): • Color vision deficiencies are inherited conditions • Color is a large component of whole group instruction in my library • Color vision deficiency is classified as a disability under Special Education guidelines
A number (1-4) to 0: • Pure primary colors are usually distinguishable by people with color deficiencies
Disagree/strongly disagree to agree/ strongly agree: • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • When color-coding, I provide the information in another way as well (shape, design, etc.) • I consider the needs of students with color vision deficiencies when designing lessons • I consider the needs of students with color vision deficiencies when decorating the library • I consider the needs of students with color vision deficiencies when designing Power Point slides

Two of the items which changed from *do not know* to agreement were related to general knowledge about color vision deficiencies. The third item was related to the use of color as part of whole group instruction. Item 4-1r, "In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school," had a

change from disagree to agree, which is an inaccurate response. The other items that changed were related to Lottie's considerations and accommodations for students with color vision deficiencies. The change in these areas suggests a change in attitude or understanding about the needs of these students.

When the researcher arrived for the post-observation, Lottie was excited to show some books she had just ordered about color vision deficiencies. She also ordered an Ishihara color vision card and book set that she planned to have at a reading station for student to look through in their free time in the library to raise awareness of color vision deficiencies. As she said on the post-test, "I will be more on the lookout for possible color vision deficient students." It was apparent through this animated discussion that Lottie's attitude about color vision deficiencies had changed as her knowledge increased, causing her to make changes in her library program.

Lottie's attitude scale scores increased slightly from pretest ($\mu = 2.83$) to post-test ($\mu = 2.95$). Many of the items did not change between the two tests, but those that did change are shown in Table V3.

Table V3

Lottie - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4):
• Training about color vision deficiencies would be helpful for educators
• The inability to identify colors may be due to carelessness, not color vision deficiencies
• People with color vision deficiencies learn to compensate on their own
A number (1-4) to 0:
• Children with color vision deficiencies should be guided to interests in which color discrimination is not important
• People with color vision deficiencies should have a 504 or IEP
• Students with color vision deficiencies will ask other students for help in the library if needed
• Students with color vision deficiencies ask for help when needed
Affect/strongly affect to not affect/strongly not affect:
• To what degree do you think color vision may affect following directional signs in the library
Disagree/strongly disagree to agree/strongly agree:
• I have thought about the needs of color vision deficient students before this survey
• If a child cannot identify colors when tested, it may be because he/she did not understand the test

Lottie indicated in the post-test that training about color vision deficiencies would be helpful for teachers. She changed to a *do not know* response for four items, two of which were both related to students asking for help. Lottie changed her attitude about the affect color vision on following directional signs to disagreement. As mentioned in the discussion of her directional signage, Lottie's signs use high contrast colors.

APPENDIX W

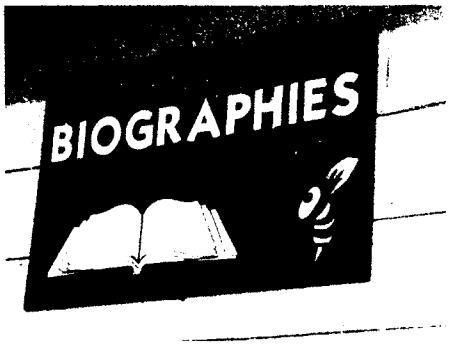
CASE #7: JANICE

The library at Harrison Elementary is a bright, open space with a high ceiling and decor to simulate an outdoor feeling. There is a large skylight that brings natural light into the interior room with no other exterior windows. The reading area is in the far back corner, under a lower ceiling. There is a large blue oval rug, a teacher's chair, and a flannel board. On the wall in this area is a large projection screen.

There is not a large use of color in the library space for purposes other than aesthetics. Throughout the library, the bookshelves have labels on the top shelf that are grey with black lettering which provide good contrast. There are some colored subject labels on the spines of some books, but the labels also have the subject written in text and include a picture.

Figure W1

Signage with High Contrast



Some connotative uses of color are present in the library, which could lead to confusion in students with color vision deficiencies. The graphic novels have yellow spine labels, and many books in the picture book section have blue dots. This school does

not use Accelerated Reader, and there is no indication of the meaning of the blue dots. Reference books have a large yellow spine label that includes a large letter R.

In the interview, Janice indicated that she does not have any knowledge of color vision deficiencies other than to say, "You know, just the fact that some people are color blind and that they can't differentiate all the colors, but that's pretty much it. I don't really have a huge background knowledge of that." She said she has not known any students or others with color vision deficiencies, and added, "I don't know if I would have that knowledge. I don't know if that would come up unless it was really affecting their learning in some way."

The pre-observation and post-observation were coded for reference to color, description of pictures, and questions about pictures. The results of the two observations are shown in Table W1.

Table W1

Janice - Occurrences of Coded Data in Pre- and Post-Observations

Code	Pre-observation occurrences	Post-observation occurrences
Reference to color	0	5
Descriptions of images or pictures	9	6
Questions about the images or pictures	2	6

In the pre-observation, there were no references to color. However, Janice did describe pictures to the students as she was reading the story. The book she read in this story, *Balloons Over Broadway*, was a graphic novel design and included many small colored images on many of the pages. Janice pointed out many of the smaller images to draw the students' attention to the images and described them as she read. In the post-

observation, Janice read *The Quilt Story* which included some references to color, most of which were describing an object, such as, "She stitched the quilt by a long, yellow flame." Again, Janice described the pictures and asked questions to encourage the students to think about what was happening in the pictures. At one point, she asked a question and then told the students to "look for your clues in the illustrations." Most of the references to color in both of the stories were aesthetic, not providing information that was necessary to understand the story.

Janice's scores on the knowledge scale increased slightly from pretest ($\mu = 2.90$) to post-test ($\mu = 3.00$). Most of the items remained unchanged, but the items that changed are presented in Table W2.

Table W2

Janice - Change in Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
0 to a number (1-4): • Color vision deficiencies are inherited conditions • Color vision deficiencies can be corrected with treatment • Color vision deficiency is classified as a disability under Special Education guidelines
A number (1-4) to 0: • The library website is visually accessible to all users
Disagree/strongly disagree to agree/ strongly agree: • I consider the needs of students with color vision deficiencies when designing lessons • I consider the needs of students with color vision deficiencies when decorating the library • I consider the needs of students with color vision deficiencies when designing Power Point slides
Agree/strongly agree to disagree/strongly disagree: • Pure primary colors are usually distinguishable by people with color deficiencies • Color is a large component of whole group instruction in my library

Janice indicated *do not know* for three items on the pretest, and all three of these items changed to a level of agreement on the post-test. All three of these items were related to general knowledge about color vision deficiencies. One item changed from a scaled number to a zero response and was related to the accessibility of the library website. Janice's responses on all three of the items regarding her consideration of the needs of students with color vision deficiencies changed from disagree to agree, suggesting a change in knowledge. In a blog post, Janice commented,

> "I was unaware of the pervasiveness of color vision deficiencies in boys and how it can affect their learning. I love the idea of universal design in learning and the idea of designing lessons from the get go that can be accessible by many learners."

She went on to add, "I will be more aware of how to construct the stations in my library, especially the paper based ones."

Janice's scores for the attitude scale decreased slightly from pretest ($\mu = 2.68$) to post-test ($\mu = 2.46$). The items that changed are shown in Table W3.

Table W3

Janice – Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4): • Special Education teachers provide accommodations for students with color vision deficiencies • Students with color vision deficiencies are receiving assistance/support from parents • Students with color vision deficiencies are receiving assistance/support from teachers
A number (1-4) to 0: • Children with color vision deficiencies should be guided to interests in which color discrimination is not important • People with color vision deficiencies should have a 504 or IEP
Agree/strongly agree to disagree/strongly disagree: • Color-coding is a helpful way to categorize information • People with color vision deficiencies know they see the world differently than others • To what degree do you think color vision may affect finding a book on the shelf • To what degree do you think color vision may affect following directional signs in the library
Disagree/strongly disagree to agree/strongly agree: • I feel sorry for people with color vision deficiencies, who cannot see all of the colors I see • If a child cannot identify colors when tested, it may be because he/she did not understand the test

It is interesting to note that the three items about accommodations provided by others for students with color vision deficiencies all changed from zero to disagree, suggesting a negative attitude about the assistance the students are receiving. According to research presented in the training session, this is an accurate depiction of the low level of support that is typically provided to students with color vision deficiencies. Her response may not be a direct reflection of her school.

Two of the items for which Janice changed to disagree were related specifically to her library. As noted in the description of the library at Harrison Elementary School, the book levels are not coded for a reading program like Accelerated Reader, and there are

very few directional signs in this space. Janice addressed this on the post-test when she said, "I haven't made too many changes because my signs use a variety of images, color and text to highlight information." She also said, "I will now make sure to have signage and instruction with color be a combination of color as well as text and perhaps images."

APPENDIX X

CASE #8: SUSAN

The octagonal-shaped library at Hayes Elementary School is a small interior room, but is brightly lit by a large skylight in the center of the room. Movable bookshelves are placed around the outside of the room. There are a few small rooms off of the main space that house the reference collection, a bank of computers, and the story area. Small posters on the top of some bookshelves give direction to the various sections of the library.

Most of the directional signs in the library have strong contrast, using color for aesthetic purposes. The high contrast is helpful for students with color vision deficiencies. There are large letters on the end caps of some bookshelves, and a long "FICTION" poster on one shelf. Black stickers are located on the end of many shelves giving the author initials that can be found on that shelf. In the non-fiction section, there are categories written on small white labels with black ink on some shelves along with the Dewey Decimal numbers. The reference books have either R or REF on the spine label.

There are a few locations within the library space that could cause confusion for students with color vision deficiencies. Hayes Elementary School uses the Accelerated Reader program, and the included in the program are color coded with colored spine labels (red, yellow, blue, orange), with no indication of the meaning of the colors on the label. These books do have an Accelerated Reader label inside the back cover that gives the book level. This connotative use of color is one that may not be noticed by students with color vision deficiencies. In the story area, there is a colorful world map on the wall

and book jackets displayed on the windows behind the librarian's chair. These items, if used as part of instruction, could be confusing for students with color vision deficiencies. There is a colorful rug for the story time seating; the color appears to be for aesthetic purposes and would not pose a problem for students with color vision deficiencies.

Due to a scheduling conflict, Susan was not available for the interview at the original time, so the researcher agreed to meet her prior to the training session. However, Susan later asked not to participate at this time either. Therefore, no interview data are available for Susan. When the researcher contacted Susan after the training to arrange the post-observation, Susan stated that nothing had changed so there was nothing to observe. Respecting her right to choose not to participate at any point in the study, the researcher did not press the issue, but did ask Susan if she would be willing to complete the online post-test. Susan happily agreed, so post-test data are available.

During the observation, Susan read two stories to the kindergarten class that were both related to gifts. In this lesson, she made three references to color, described the pictures nine times, and asked questions about pictures eight times. Susan used many more questioning techniques to get the students thinking about what might happen next in the story, such as "Do you think they knew each other?" These questions were not related to specific pictures, but to the storyline, so they were not included in the coding for questions related to the pictures.

Susan's scores on the knowledge scale increased from pretest ($\mu = 2.50$) to post-test ($\mu = 3.05$). There were a number of items with considerable changes, as seen in Table X1.

Table X1

Susan - Change in Scores from Pretest to Post-Test, Knowledge Items

Items that changed from
0 to a number (1-4): • Color vision deficiency means the person sees everything in black and white • Color vision deficiencies can be corrected with treatment • All people with color vision deficiencies see colors in the same way • Pure primary colors are usually distinguishable by people with color deficiencies • Color vision deficiencies affect a very small percentage of the population in a school • In Virginia, all children are tested for color vision deficiencies as part of the vision screening before entering school • I use instructional materials that have colors which are visually accessible to all students • Color vision deficiency is classified as a disability under Special Education guidelines
A number (1-4) to 0: • Color vision deficiencies are more prevalent in males than in females • When color-coding, I provide the information in another way as well (shape, design, etc.)
Agree/strongly agree to disagree/strongly disagree: • The name of a color (blue, green, etc.) means the same thing to all people • The library website is visually accessible to all users

As can be seen in the table, Susan responded *do not know* on seven of the knowledge items in the pretest. All of these items changed to a scaled number in the post-test indicating a change in knowledge. There were two items that Susan initially indicated a level of agreement or disagreement but changed to zero responses on the post-test. There were two items which Susan first agreed then changed to disagree.

Susan showed a decrease in scores on the attitude scale for pretest ($\mu = 2.73$) to post-test ($\mu = 2.2$). However, many of these items were scored as zero in the pretest, which was coded as a missing value so these were not calculated in the mean score. As seen in Table X2, most of these zero scores became scaled numbers in the post-test.

Table X2

Susan - Change in Scores from Pretest to Post-Test, Attitude Items

Attitude items that changed from
0 to a number (1-4):
• People with color vision deficiencies know they see the world differently than others
• People with color vision deficiencies learn to compensate on their own
• People with color vision deficiencies should have a 504 or IEP
• Students with color vision deficiencies will ask other students for help in the library if needed
• Adding the color name when color-coding is helpful
• To what degree do you think color vision may affect reading a map
• To what degree do you think color vision may affect reading a picture book
• To what degree do you think color vision may affect reading a graph or chart
• To what degree do you think color vision may affect finding a book on the shelf
• To what degree do you think color vision may affect playing a board game
• To what degree do you think color vision may affect completing a puzzle
• To what degree do you think color vision may affect Playing a game on the computer
• To what degree do you think color vision may affect Following directional signs in the library
• Special Education teachers provide accommodations for students with color vision deficiencies
• Students with color vision deficiencies are receiving assistance/support from parents
• Students with color vision deficiencies are receiving assistance/support from teachers
• Students with color vision deficiencies ask for help when needed
Agree/strongly agree to disagree/strongly disagree:
• Color vision deficiencies are discussed in Education courses in college
• Color-coding is a helpful way to categorize information
• I have thought about the needs of color vision deficient students before this survey
Disagree/strongly disagree to agree/ strongly agree:
• If I suspected a student was color vision deficient, I would know how to help him/her

As can be seen in the table above, there were seventeen items which Susan originally indicated *do not know* on the pretest, then changed to a level of agreement in the post-test. This suggests a large change in attitude or understanding related to color vision deficiencies. There were an additional three items which remained as zero responses in the pretest and the post-test. The items that Susan changed from agree to disagree were interesting to note as well, suggesting an additional change in attitude. It is also interesting to note that Susan indicating a strong agreement with her change in the ability to help someone with color vision deficiencies after the training session. In the post-test, she commented, "I have wondered who might have a color deficiency," and "I think about color when I write on my white board." Although Susan did not participate in all of the elements of the case study, her pretest and post-test results show a change in her knowledge and attitudes or understandings about color vision deficiencies.

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PRESENTATIONS AND PUBLICATIONS

Collins, K. B., Doll, C. A. (2012). Resource provisions of a high school library. *School Library Research.*

Collins, K, Knowles, A, Molnar, J. (2012). Finding your way using QR codes. *Library Media Connection.*

Collins, K. (January 2013). Addressing the needs of learners with color vision deficiencies in the school library. Works-in-progress poster presentation. ALISE National Conference, Seattle, WA.

Collins, K. (December, 2012). What color is a rainbow? Faculty in-service training. Williamsburg-James City County Schools.

Collins, K. (November, 2012). What color is a rainbow? Conference presentation. VAASL Fall Conference. Hampton, VA.

Collins, K., DeGroft, L., Knowles, A., Molnar, J. (November, 2012). Finding their way using QR codes. Conference presentation. VAASL Fall Conference, Hampton, VA.

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