# Color Universal Design for Educators: An Instructional Design Research Project

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**Abstract:** Is it imperative that inclusive learning materials are created to ensure all students, whether in-person or in online learning environments, have access to a quality education. Creating visually inclusive learning materials for students with disabilities, in particular, students with colorblindness, will help with academic success. However, many educators are unaware of their students with colorblindness and few know how to create inclusive visual materials for them. Color Universal Design, a relatively new approach under the conceptual umbrella of Universal Design and Universal Design for Learning, can help. Therefore, the purpose of this research study was to create and evaluate the effectiveness of an online instructional module on Color Universal Design for post-secondary educators. This module aimed to increase awareness of students with colorblindness and teach Color Universal Design techniques. Disseminated to a sample population of post-secondary educators of the University of Hawai'i system, pre- and post-assessments were used to evaluate participants' application mastery of the module's content and to measure the overall instructional effectiveness. Color Universal Design can assist educators with steps to improve their visual materials, decrease learning barriers for their students with colorblindness, and enhance the experience of all their students.

"When you include the extremes of everybody, that's to say differently abled people of all sorts, then you produce things that are better for all of us"
*- Michael Wolff (Caltenco, Hedvall, & Larsson, 2014)*

## Introduction

The rapid advancements in technology and online interaction are creating more opportunities for students with disabilities in postsecondary education. In the United States, postsecondary institutions online enrollment has grown from 9.6% in 2002 to 32% in 2011 (Allen, Seaman & Sloan, 2013). With these increases there is also a heightened reliance on visual materials conveying information (Brejerano, 2008; National Education Association, 2013). Yet many educators have not been trained or are unaware of how to effectively develop visual educational materials, especially for students with visual disabilities such as those with visual impairments, dyslexia or colorblindness (Petty, 2014). Though the increase of online courses can align with more opportunities and involvement of students with disabilities, unaware and untrained educators may unintentionally create barriers.

However there are techniques to assist educators in creating more inclusive visual materials, whether they teach face-to-face, hybrid or online. One of the techniques is Color Universal Design. Under the conceptual umbrella of Universal Design and Universal Design for Learning, Color Universal Design is a process of specifically designing visual materials that are friendlier to individuals with colorblindness or color deficiency. For example increasing the contrast between colored text on a colored background can improve legibility for individuals with colorblindness (Color Blind Awareness, 2014). Postsecondary educators who are aware of and use Color Universal Design can decrease barriers and make visual materials more inclusive for student with colorblindness (SWC). Thus, the purpose of this instructional design project was to develop and evaluate the efficacy of an online module on how to use basic Color Universal Design techniques. The module also aimed to increase awareness of students with colorblindness and increase knowledge about techniques to create inclusive visual materials for students with colorblindness, as well as for all students.

## Literature Review

The underpinning of this project was a literature review focused on five main categories: 1. conceptual theory, 2. type of project, 3. content, 4. design strategy, and 5. current research. Figure 1, below, outlines the relationship between the five literature review categories and the development of the instructional module.

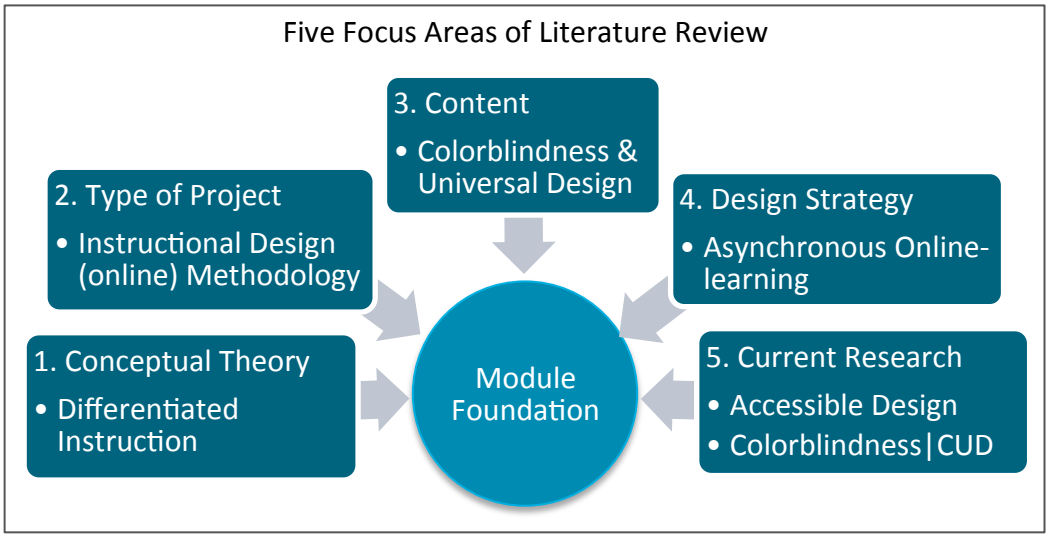


*Figure 1.* Literature review process to create module design foundation. Color Universal Design (CUD).

*Conceptual Theory – Differentiated Instruction*

As with all education differentiated instruction is imperative to consider, address and provide instruction for various learning styles from visual, to kinesthetic to auditory. Addressing the various learning styles in an online environment creates a unique challenge (Bonk & Zhang, 2006; Brejerano, 2008). A conceptual theory for an e-learning environment that addresses various learning styles must be organized, with activities and content development aligned with the effective use of technology (Bonk & Zhang, 2006; Lee, & Lee, 2012). The module's conceptual theory stemmed from synthesizing old and new theories including applying Gagné's Nine Events of Instruction to e-learning for organization and using aspects of the R2D2 (read, reflect, display, and do) for activity development (Bonk & Zhang, 2006). This was done through combining elements such as sections for attention grabbing, areas to read, stimulate recall, performance practice and feedback. Also via the online platform, text and images, interactivity, audio and video were used.

*Type of Project - Instructional Design (online) Methodology*

The methodology for creating an online instructional design module and/or e-learning experience varies; however, an effective approach is backward instructional design. This approach ensures effectiveness by identifying first the desired results, the acceptable evidence to verify results and pre-planning learning experiences to align design (Brown, Eaton, Jacobsen, Roy & Friesen, 2013). To further support an effective instructional

design is the process of how the material is presented - adding supportive and appropriate learning aids such as layouts, graphics and visual aesthetics (Kollman & Hardré, 2013). This online instructional design methodology and the previously mentioned instructional design theories were combined to enhance learners' experience and skill development. First examining the theoretical instruction process, assessing desired results and examining backwards to assess if the process would meets those results.

*Content – Colorblindness & UD*

Many SWC do not self-identify or are unaware of their status. Moreover educators are unaware of their SWC needs causing colorblindness to remain a hidden disability and unaddressed. Colorblind students often struggle in the classroom because colorblindness is not considered a special education and/or disability need. Both teachers and parents are rarely given training on how to help (Color Blind Awareness, 2014; Fong, 2013). Universal Design and Universal Design for Learning aid in creating awareness about reducing barriers for individuals in the educational environment (Center on Universal Design, 2008; Hehir, 2009). They offer modifications for reducing and removing the barriers SWC may face (Hehir, 2009; Stiles, 2006; WebAim, 2013). Therefore the content of the module was structured by first providing information to create awareness about individuals/SWC, the barriers they face, and then skill development for how educators can reduce those barriers.

*Design Strategies – Asynchronous Online-learning*

Without an instructor or facilitator present to engage or monitor learners, the asynchronous online-learning environment needed to be meticulously developed to ensure effective self-directed learning. This is done not only from the instructional design and content development perspective but also for usability and interactivity (Kidd & Song, 2008; United States Department of Labor, 2011). Furthermore, to ensure content retention, audience engagement, and learning reinforcement in asynchronous online-learning, best practices from the design to evaluation phases were followed and implemented (United States Department of Labor, 2011). To construct elements such as interactive content, supportive navigation tools, effective accessible visual design, and design for learning, emphasis was placed on the following formula for design: *e-learning design guidelines + usability + instructional design = inspire motivation to learn.*

*Current Research – Accessible E-Instructional Design*

A current research review was conducted in a two-pronged effort, first to identify appropriate options for online universal instructional design, learning management systems (LMS) and accessible software applications. Next was to examine current research regarding content, including individuals with colorblindness and CUD. Elias (2010) suggested that universal instructional design for distance education is vital. The design must align with the needs of instructors, students and designers but also with delivery on accessible platforms. These platforms then can be incorporated with an LMS to monitor learner progress and overall efficiency (Elias, 2010). This consideration was at the forefront of the module's development in choosing the LMS platform, accessibility design and interactivity. Several platforms and LMS systems were researched and evaluated, which are further discussed in the *Project Design* section.

*Current Research – Colorblindness and CUD*
Research on colorblindness and CUD from *Color Vision Deficiency in Preschool Children* supported not only the current prevalence of SWC but also the future rate, which is at least three out of 50 non-Hispanic white children; meaning around five potential students out of 50 may have colorblindness (Xie, Tarczy-Hornoch, Lin, Cotter, Torres & Varma, 2014).

Okabe and Ito (2008) concentrated on how to improve visual materials for individuals with colorblindness. The research done by Okabe and Ito, '3+1 CUD Principals' (below) generated the initial interest and idea of this project.

1. Choose color schemes that can be easily identified by people with all types of color vision.
2. Use not only different colors but also a combination of different shapes, positions, line types and coloring patterns, to ensure that information is conveyed to all users including those who cannot distinguish differences in color.
3. Clearly state color names where users are expected to use color names in communication.

+1. Aim for visually friendly and beautiful designs (Color Universal Design Organization, 2006; Okabe & Ito, 2008).

## Project Design

### Target Audience

The target audience for this module included male and female educators (K-12, higher education to business educators) who use colored, print or visuals materials to convey information. More specifically educators who consciously want to be more thoughtful while creating visual materials that are inclusive for individuals with colorblindness (IWC). Trainees of this module may also have a broader interest in learning the guidelines of the 508 Rehabilitation Act standards and Web Content Accessibility Guidelines (WCAG) 2.0

At minimum, trainees completing this module should gain the knowledge and ability to differentiate the meaning and terms of basic colors, background and text, and general understanding of colorblindness. Trainees should have prior experience in creating visual materials to convey information. The targeted audience is further delineated into learner characteristics that include: cognitive characteristics, physiological characteristics, affective characteristics, and social characteristics in Figure 2 (see Figure 2 below - Learner Characteristics of the Target Audience). These characteristics were taken into account in designing the module.

| Learner Characteristics of the Target Audience | |
|---|---|
| 1. Cognitive | 2. Physiological |
| • At a Formal operational stage<br>• General Form Perception, Learning and Verbal Ability<br>• Limited design, UDL, UD, or CUD background<br>• Limited color theory background<br>• Limited understanding of colorblindness | • Approximate age 19 and up<br>• Individuals who are and are not colorblind<br>• Average visual perception and/or eyesight<br>• Able to perform motor tasks associated with online learning |
| 3. Affective | 4. Social |
| • Genuine interest in learning<br>• Genuine interest in reaching all students and a belief they can make a difference<br>• Interest in creating more effective visual educational materials<br>• Genuine interest in decreasing barriers for students with colorblindness<br>• Open to learning and integrating a new techniques to support them being more inclusive educators | • Middle to high socioeconomic status<br>• Educators (K-12, higher ed. and business education)<br>• Anyone creating visual educational materials<br>• Equipped with computer with internet connection<br>• Individuals with diverse demographic backgrounds |

*Figure 2.* Learner characteristics of the target audience. Universal Design for Learning (UDL), Universal Design (UD) and Color Universal Design (CUD).

**Content Development**

Content was developed with the terminal level goal for participants to understand and learn the skills to appropriately use two CUD techniques. The two techniques included; 1.) suitable color contrast and 2.) effective use of color to convey meaning. The learning objective was for them to be able to improve visual materials for SWC and also improve their visual materials for all students. The sub-learning objectives include learning about colorblindness, and the general principals of, UD and CUD. In order to achieve said objectives this module was presented in four sections (1) IWC CUD/UD needs, (2) Color Contrast, (3) Color to Convey Information, and (4) Techniques Practice. For supportive content a fifth online section was created for videos.

**Online Content Development**

The main content (sections 1-4) was developed using Articulate Storyline, which is an e-learning authoring software and then embedded within Canvas, a learning management system (LMS). Canvas also housed sign-up, an informational landing page, a certificate of completion and data collection via pre- and post assessments and surveys. Over a five month period module development focused on:

- Research and developing appropriate content
- Using effective online strategies for,
    - Instructional design
    - Adult learners
    - Self-directed and asynchronous online learning
    - Accessibility
- Creating original theme and images
- Designing images and visuals under UD and CUD guidelines (font sizes, color combinations, spacing and design consistency).
- Designing functional content interactivity such as creating buttons, triggers, layers, text-submit areas and pop-ups.

The design theme incorporated the sections as locations in a town setting. Learners could interactively move through the locations of the town (sections) to gain information and skill development. The module's theme and sections overview, including learning objectives were as follows, and is visually presented in Figure 3:

Module Menu and Theme Name: Town of Color Universal Design

- Section 1 - Food For Thought Restaurant: An introduction to SWC, UD and CUD.
    - *Sub-learning objective*: To gain general understanding of colorblindness, UD and CUD. This section included 'what is colorblindness' and 'who and frequency of individuals that may have colorblindness' and, 'what' is UD/CUD, why they are important and relevant.

- Sections 2 and 3 - C & C Café: Where participants gained knowledge and practiced techniques to properly use color contrast and color to convey information.
    - *Main learning objectives*: Here learners were presented with two basic CUD techniques on how to use color in their visual materials. They were also offered interactive practice areas (practice tests) to self-assess their knowledge on using the two techniques.

- Section 4 - CUD Academy: Offered terminal level techniques practice.
    - *Terminal learning objective*: Presented with three scenarios, here participants were asked to correctly use techniques to improve visual materials for SWC. This was a self-test to assess overall skill development.

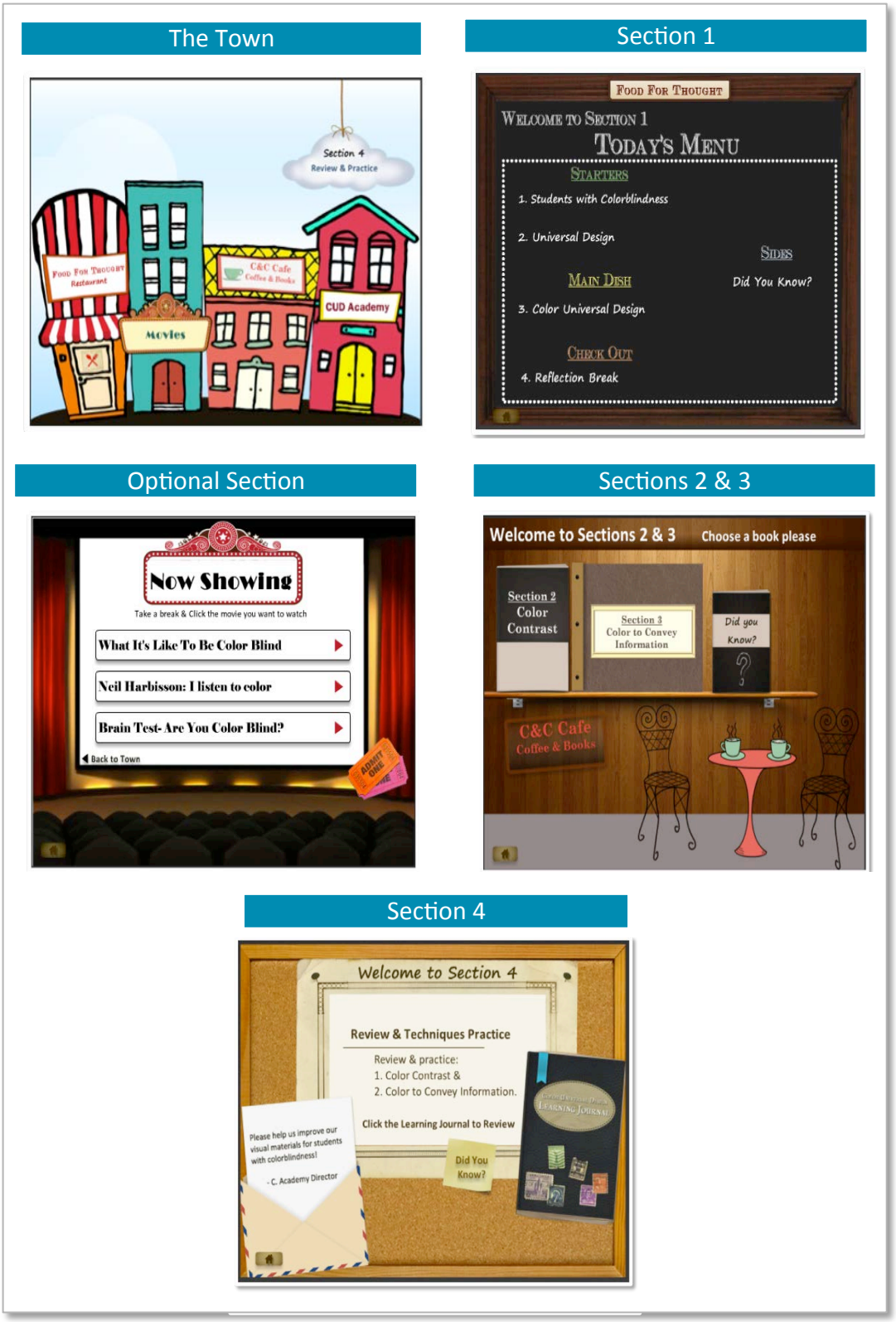


*Figure 3.* The modules' main sections in Articulate Storyline.

Also, at the beginning of each section were areas called ‘Did You Know’ used for attention grabbing and to initiate further inquiry, shown in Figure 4. Another example would be; did you know Facebook is blue because founder Mark Zuckerberg is red-green colorblind? Which means blue is the best color he can see (Vargas, 2010). Participants could hover over the areas and content and images would appear.

At the end of sections 1-3 there were practice tests called ‘Reflection Breaks’ where participants could self-assess their content knowledge of the preceding learning content (see Figure 4, Reflection Break area). After reading questions they could click an answer then push a ‘submit’ button. If the answer was incorrect they were given feedback on why it was incorrect and asked to try again. If the answer was correct they were told why and to move forward. Similarly in Figure 4 – *Other Interactivity* shows an example where participants could click buttons to see unsuitable and suitable versions of visuals (charts, graphs and maps) and options to check for the proper use of color to convey information.

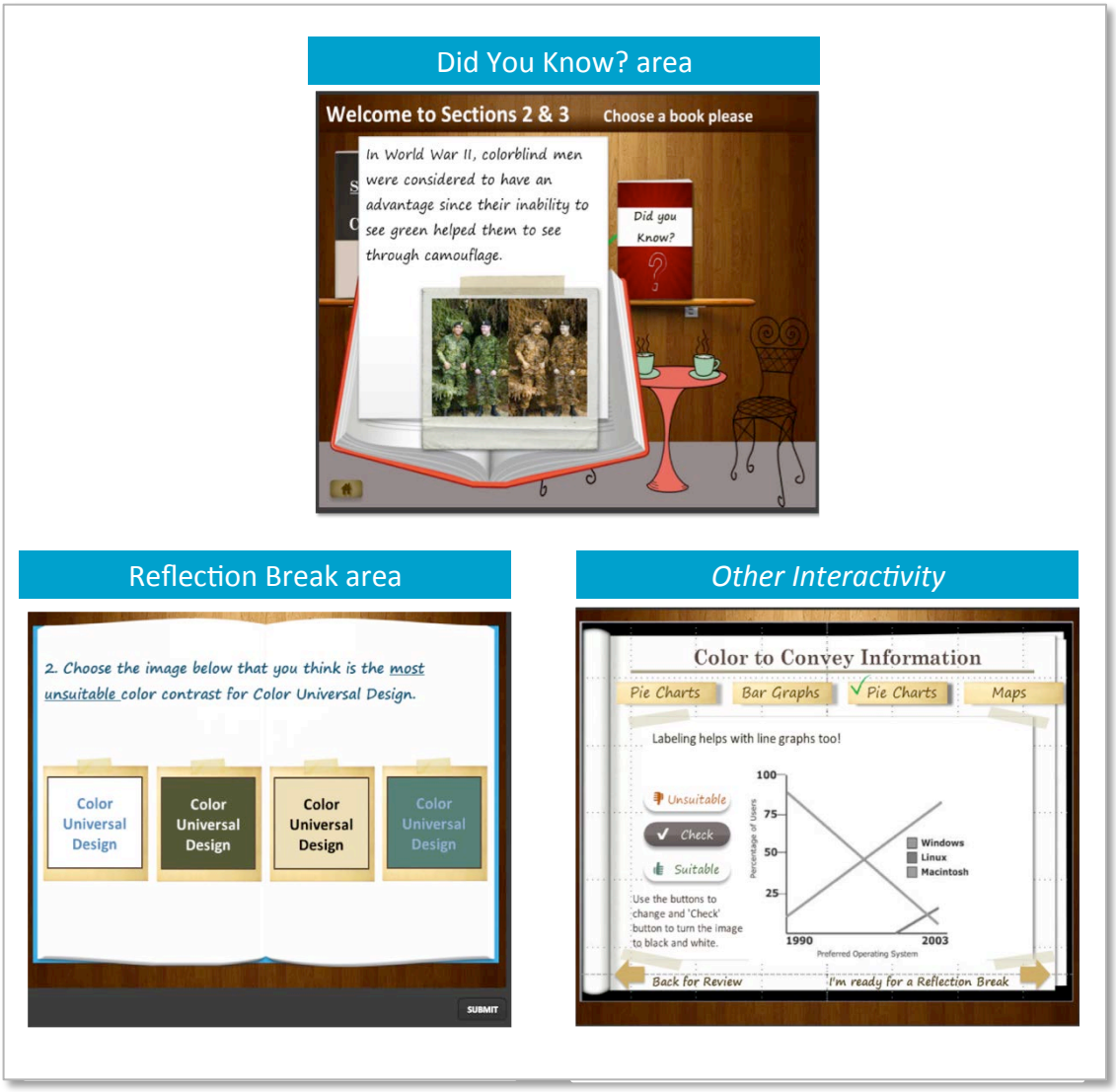


*Figure 4.* Examples of interactive learning areas of the module.

Once completed, the Articulate Storyline content was embedded into Canvas. The elements and process created in Canvas comprised of 1. an informational landing page and participant consent form, 2. an overview and directions page, 3. pre-survey and assessment, 4. module content (original theme, five sections and over 156 interactive layers), 5. post assessments and survey and a 6. certificate of completion (see Appendix A, Module Structure and Process in Canvas).

## Methods

The sample population recruited to evaluate the module was post-secondary educators of the University of Hawai'i system (10 campuses), teaching any subject area, from diverse socioeconomic and ethnic backgrounds. Participation was open to those who taught in-person, hybrid, online hybrid or only online courses and ages ranging from 25 to 70.

A recruitment flyer with information to access to the module link via Canvas, was disseminated through emails and LISTSERVs over a four-week period (see Appendix B, Project Flyer). With the link participants could enroll in the Canvas module with a personal login. Once participants logged-in there was a welcome presented on the landing page including the project purpose and consent information, which was also downloadable. Though the estimated time of completion included approximately 45 minutes, it was conveyed that participants could take the module at their own leisure. For instance they could start and stop, login and log-out, as they needed.

### Data Collection Process

The instruments, including pre- and post surveys and pre- and post assessments were used to collect quantitative data. Qualitative data were collected through the post-survey optional feedback area. Figure 5 illustrates the data collection process. Canvas allowed data to be collected in real-time as it was submitted electronically. The data were then downloaded as comma-separated values (CSV) and converted into Excel spreadsheets for analysis.

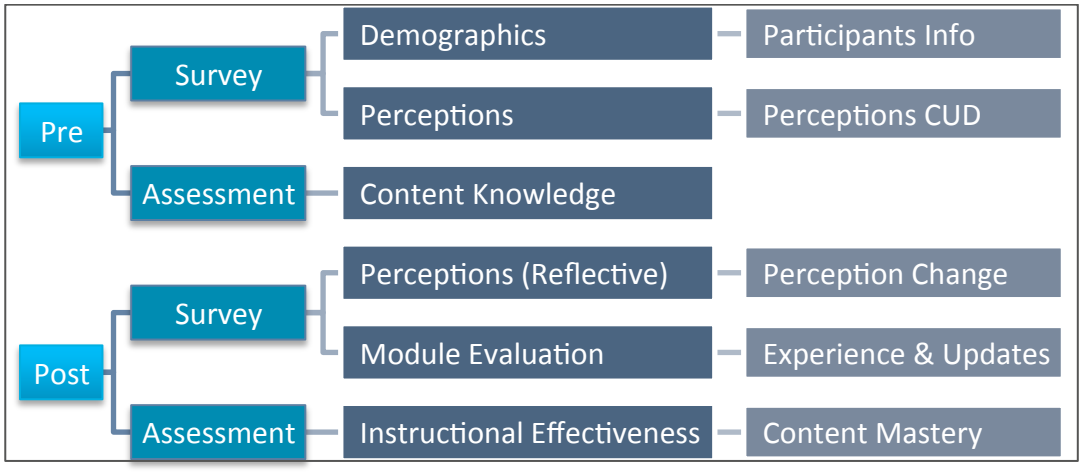


*Figure 5.* A diagram of the instruments and data collection process.

## Instruments

1. Pre-survey was used to acquire demographic and pre-perceptions (knowledge, skills and attitudes) about UD and CUD. (13 questions total)
2. Post-survey was used to acquire post-perceptions and compare changes in knowledge, skills and attitudes about UD and CUD. The post survey was also used to evaluate participants' overall experience taking the module and to identify future revisions or updates. (9 questions total)
3. Pre-Assessment was used to measure entry-level knowledge and awareness about the needs of SWC, knowledge about UD and CUD, and skills using color contrast and color to convey information. (11 questions total). Assessment constructs included questions one through four to evaluate sub-objectives, which were the general understanding of colorblindness, UD and CUD. Questions five to seven were on the main objective (properly using color contrast and questions) and the other main objective in eight and nine (properly using color to convey information). The terminal objective was evaluated in questions 10 and 11.
4. Post-Assessment, identical to the Pre-Assessment, was used to measure the learning as a result of the course experience, and target any instructional needs to improve the module. The Pre- and Post-assessments together were used to evaluate participants' application mastery of the module's content and to measure the overall instructional effectiveness (same 11 questions as pre).

## Results

At total of 20 participants logged-in to Canvas and took the pre-survey and assessment and 13 completed the entire module. Data are presented only for the 13 who completed the module. Shown in Figure 6, participants included six females and seven males primarily between the ages of 25-44 and 55-64. Participants were educators from diverse subject areas (11) and used different course delivery models including in-person (5), online (3) and hybrid (3). Though five reported knowing about UD only two reported knowing about CUD.

| Demographic | | Teaching Background | | | | Previous Awareness | |
|---|---|---|---|---|---|---|---|
| Sex | | Subject | | Type of Course | | Aware of Universal Design | |
| Male | 7 | Language | 2 | In-person | 5 | Yes | 5 (38.5%) |
| Female | 6 | Social sciences | 1 | Online | 3 | No | 8 (61.5%) |
| Age | | Math | 2 | Hybrid | 3 | | |
| ≤ 25 | 0 | Communications | 1 | No Answer | 2 | Aware of Color Universal Design | |
| 25 – 34 | 6 | Dental | 1 | | | | |
| 35 – 44 | 2 | Art History | 1 | | | Yes | 2 (15.4%) |
| 45 – 54 | 1 | Sports Medicine | 1 | | | No | 11 (84.6%) |
| 55 – 64 | 4 | Disability Studies | 1 | | | | |
| ≥ 65 | 0 | Technology | 1 | | | | |
| No answer | 0 | No Answer | 2 | | | | |

*Figure 6*. Participants' demographic responses. Total sample size, n=13

**Participant Perceptions**

Figure 7 shows a comparison of participants pre- and post perceptions on their knowledge level regarding CUD and UD, and the frequency of use, the importance of and interest in CUD. Using a 5-point Likert scale, 12 participants rated their knowledge level about UD as an average of 'not very much' and all but 1 participant rating as 'not knowing' about CUD. The average pre-perception ratings on frequency of use (1.38), the importance of CUD (1.85) and ease of using CUD (1.31) were all less than two points. However, nine participants indicated they were 'somewhat to very interested' in CUD.

After taking the module all ratings increased with 11 participants rating their knowledge level as 'somewhat to very knowledgeable' with mean ratings on UD (3.38) and CUD (3.46) improving. Participant perceptions on the importance of CUD showed the largest change increasing from an average of 1.85 to 4.54 points. Interest level saw the smallest amount of change between pre and post with only a .77 point increase.

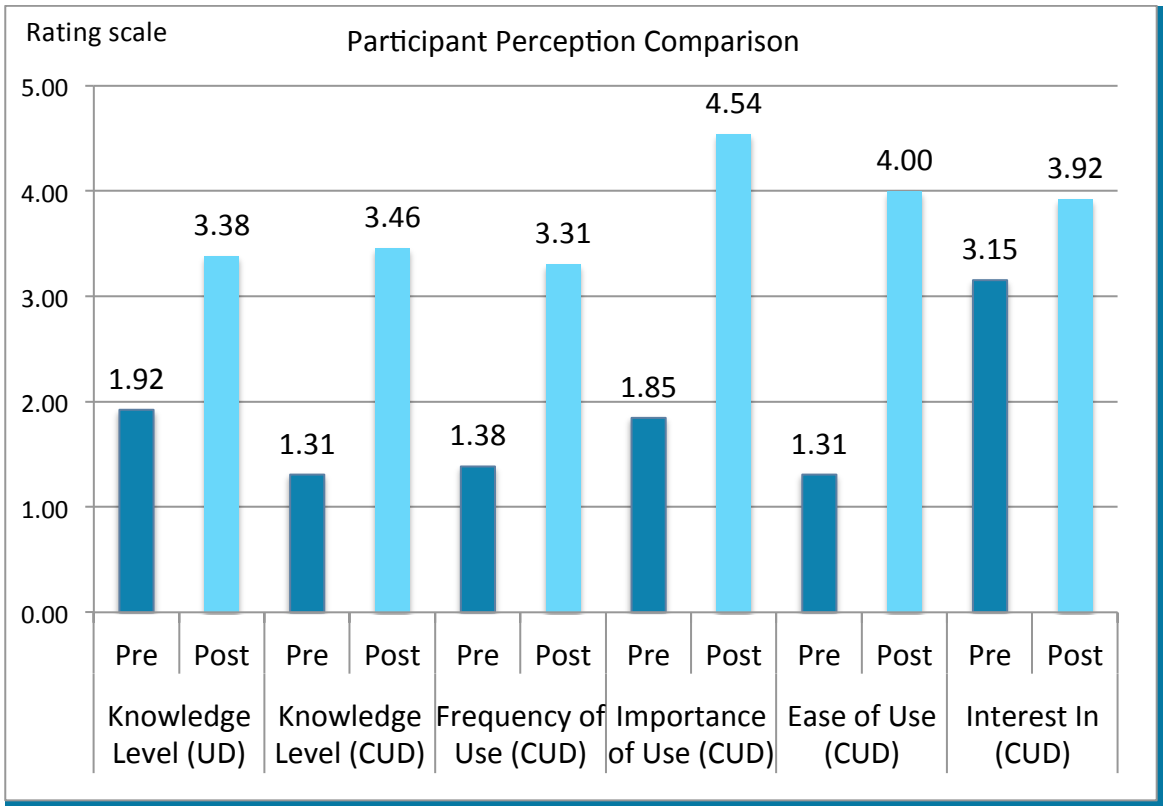


*Figure 7*. Perceptions on color and universal design. Total sample size, n=13. Scores based of a Likert 5-point rating scale. Source table in Appendix C, Participant Perception Comparison.

## Participant Assessment Scores

Comparing the participants' pre-and post-assessment scores showed an improvement for 11 participants with an average 12.8% score increase, no change for participant #12 and a 14.3% decrease for participant #9. Figure 8 shows participants and a comparison between their pre- and post assessments scores. Average pre score was 76.9% (11 out of 14 points) and the post average score at 89.7% (13 out of 14 points). In the post assessment eight participants scored 90% or better and four scored 100%.

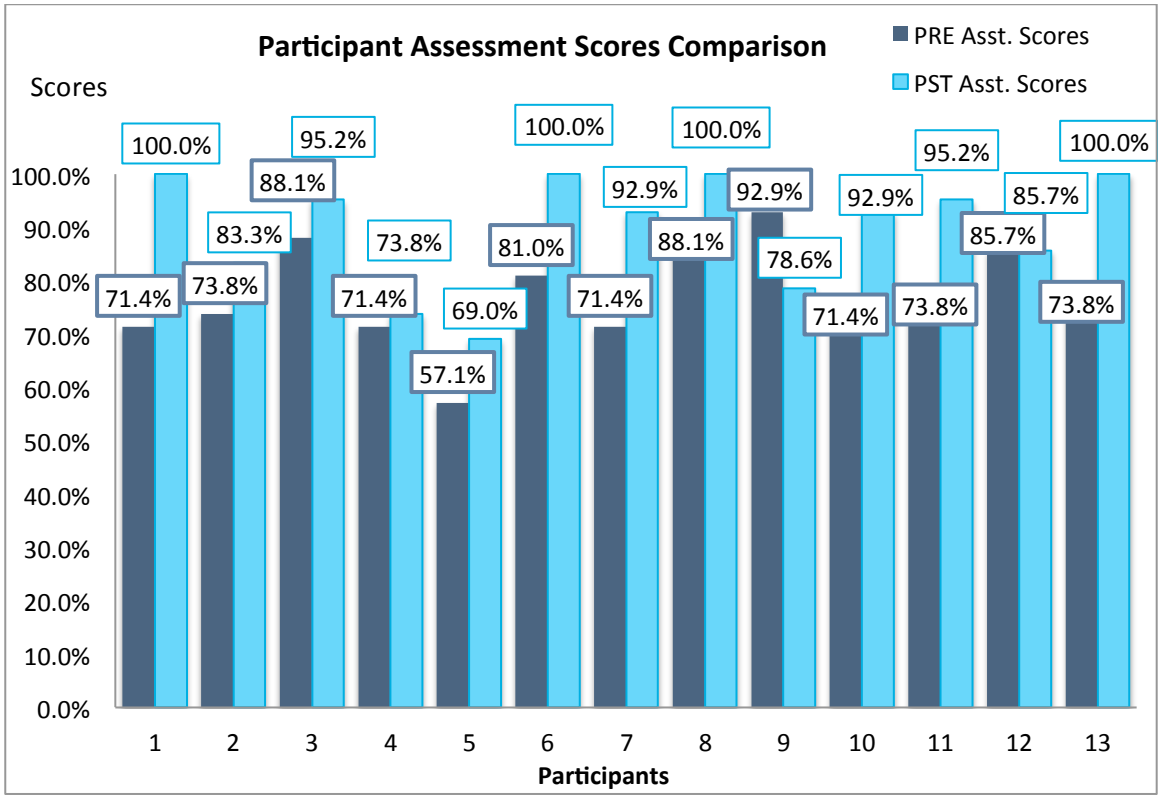


*Figure 8.* A comparison of participant pre-and post assessment scores. Total sample size, n=13 and a 100% score for both pre- and post assessments = 14 points. Source table in Appendix D, Participant Assessment Scores Comparison.

## Assessment Items

The pre-assessment data were used to evaluate pre-content knowledge and then compared to the post assessment to evaluate content mastery. Shown in Figure 9, all item scores increased other than item #6 (92.3%) score with no change. During the pre-assessment items #4 (30.8%) and #9 (38.5%) had the lowest scores. However in the post assessment both items increased, though item #4 score still sat below 70%. As expected the terminal level item # 11 had lower pre- and post scores with only a 7.7% increase. Overall most item score increased from 15 to over 30%.

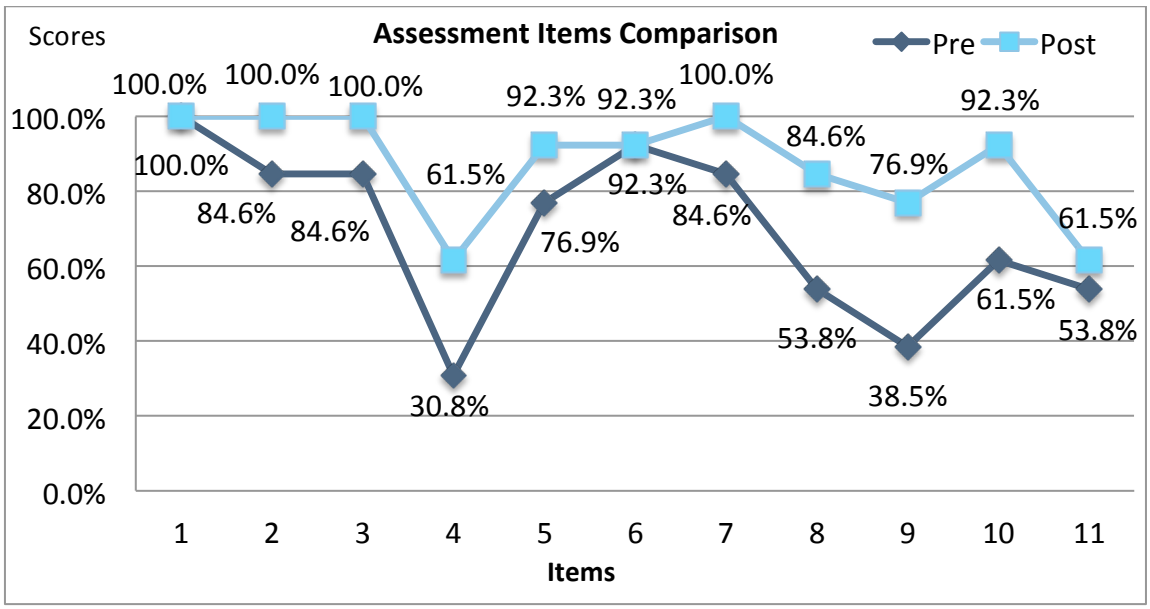


*Figure 9.* This chart shows the average scores comparison between the 11 pre –and post assessment items and/or questions 100% score = 14 points. Total sample size, n=13 and a Source table in Appendix E, Assessment Items Comparison.

**Module Evaluation**

Scores were based on a Likert 5-point rating scale, with 1=Strongly Disagree to 5=Strongly Agree. All module evaluation constructs averaged a 4.6 rating or higher. For example in Figure 9 below all participants somewhat to strongly agreed that they had a satisfying experience taking the module, learning was of quality/value, the module was engaging, kept their attention and was easy to use.

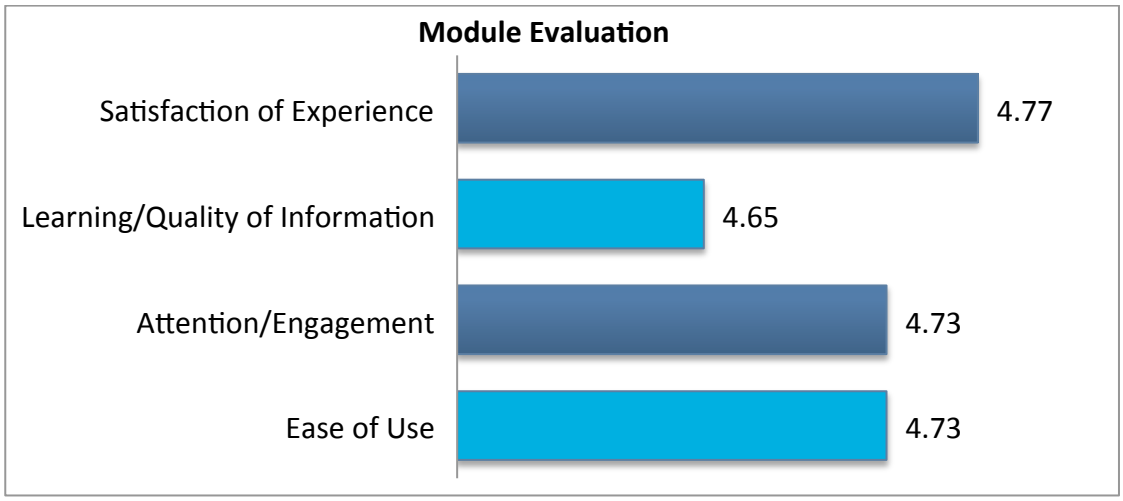


*Figure 9.* Participants feedback on their experience taking the module evaluated in four constructs . Source table in Appendix F, Module Evaluation.

Eight of the 13 participants also choose to provide qualitative feedback. The feedback showed that participants felt the module was clear, informative, and very engaging. One

participant stated, "*This was a great experience. It was an eye opener to understanding color blindness. I have family members who are colorblind and I never new these things. The graphics and content are exceptional…*". Another stated "*So interactive and applicable examples. This surely pointed me in a direction to be inclusive and aware of what I am doing for my students…*". See Appendix G for more participant feedback.

**Discussion**

There were several identifiable limitations to this study. As the extensive time needed to design and develop expanded, time for testing, reviews, editing and participant recruitment decreased. Hence, there was a slightly low sample size, functionality and grammatical errors. Moreover anomalies were seen in assessment items. In evaluation of #4, though there was a score increase the post score was still significantly low. This could be due to question wording and/or lack of effective learning content in the module.

In regard to future studies, since the content was aimed at UD and CUD accessibility and usability testing, including SWC, would have been ideal. Furthermore, conducting a focus group would have offered assistance in gaining a deeper perspective from participants. This information would be useful in making improvements to better meet the needs of learners. There also may be an interest in creating another version for a larger sample population, including K-12 educators. During project research it was found that SWC in younger grade levels have a harder time than postsecondary students. This is due to a higher dependency on color in the learning environment. It is also harder for younger students to be conscious of and communicate their needs.

## Conclusion

Based on the data collection (ratings, scores and feedback) the purpose and goals of this module were met. The increase in perception scores showed an increase in participants' awareness of students with colorblindness and importance for need for color universal design. The pre- and post assessment scores comparison showed participants gained and increased their knowledge on color universal design skills and techniques, which can improve their visual materials for students with colorblindness. The high ratings and positive feedback in the module evaluation showed that participants enjoyed taking and saw value in learning about students with colorblindness and color universal design.

These findings are important, as many times students with hidden disabilities such as colorblindness, go unnoticed and their needs unmet, causing learning barriers. The module shows that something can be done to increase awareness and when educators are presented with the techniques; they are capable of obtaining the skills to decrease barriers for students with disabilities.

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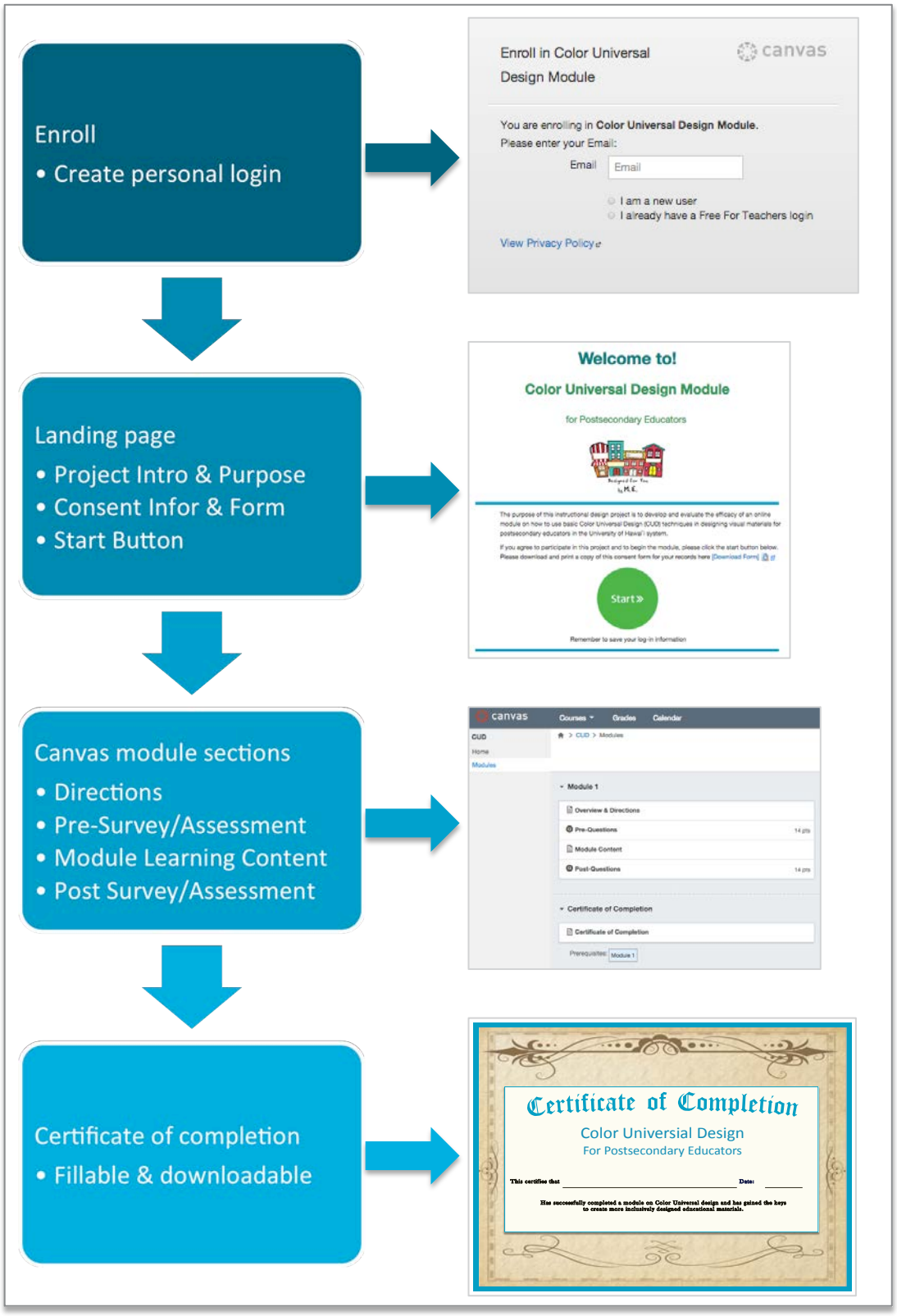
# Appendices

## Appendix A

*Module Structure and Process in Canvas*



**Appendix B**
*Project Flyer*

**Appendix C**

*Participant Perception Comparison*

*Pre- & Post Perceptions on UD & CUD*

| | | Don't Know to Not Very | Somewhat to Very | $\bar{X}$ |
|---|---|---|---|---|
| Knowledge Level (UD) | Pre | 9 (69.2%) | 4 (30.8%) | 1.92 |
| | Post | 2 (15.4%) | 11 (84.6%) | 3.38 |
| Knowledge Level (CUD) | Pre | 12 (92.3%) | 1 (7.7%) | 1.31 |
| | Post | 2 (15.4%) | 11 (84.6%) | 3.46 |
| | | Don't Know to Never | Sometimes to Very Often | $\bar{X}$ |
| Frequency of Use (CUD) | Pre | 12 (92.3%) | 1 (7.7%) | 1.38 |
| | Post | 3 (23.1%) | 10 (76.9%) | 3.31 |
| | | Don't Know to Not Important | Somewhat to Very Important | $\bar{X}$ |
| Importance of Use (CUD) | Pre | 9 (69.2%) | 4 (30.8%) | 1.85 |
| | Post | 0 (0.0%) | 13 (100.0%) | 4.54 |
| | | Don't Know to Very Difficult | Easy to Very Easy | $\bar{X}$ |
| Ease of Use (CUD) | Pre | 13 (100.0%) | 0 (0.0%) | 1.31 |
| | Post | 3 (23.1%) | 10 (76.9%) | 3.77 |
| | | Don't Know to Not Interested | Somewhat to Very Interested | $\bar{X}$ |
| Interest In (CUD) | Pre | 4 (30.8%) | 9 (69.2%) | 3.15 |
| | Post | 1 (7.7%) | 12 (92.3%) | 3.92 |

*Note.* Total sample size, n=13. Scores based of a Likert 5-point rating scale.

**Appendix D**

*Participant Assessment Scores Comparison*

*Participant Assessment Scores*

| | Q1 | | Q2 | | Q 3 | | Q 4 | | Q 5 | | Q 6 | | Q 7 | | Q 8 | | Q 9 | | Q 10 | | Q 11 | | Pre Total | | Post Total | | *Change* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ps* | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pts | % | Pts | % | Pts |
| 1. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 1 | 1 | 2 | 2 | 10 | 71.4% | 14 | 100.0% | 4 |
| 2. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 0 | 1 | 1 | 1 | 10 | 73.8% | 12 | 83.3% | 1 |
| 3. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 88.1% | 13 | 95.2% | 1 |
| 4. | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 3 | 0 | 0 | 1 | 1 | 2 | 1 | 10 | 71.4% | 10 | 73.8% | 0 |
| 5. | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 2 | 1 | 8 | 57.1% | 10 | 69.0% | 2 |
| 6. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 11 | 81.0% | 14 | 100.0% | 3 |
| 7. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | 3 | 0 | 0 | 0 | 1 | 2 | 2 | 10 | 71.4% | 13 | 92.9% | 3 |
| 8. | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 12 | 88.1% | 14 | 100.0% | 2 |
| 9. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | 13 | 92.9% | 11 | 78.6% | -2 |
| 10. | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 0 | 1 | 0 | 1 | 2 | 2 | 10 | 71.4% | 13 | 92.9% | 3 |
| 11. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 1 | 1 | 1 | 1 | 10 | 73.8% | 13 | 95.2% | 3 |
| 12. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 3 | 0 | 1 | 1 | 1 | 2 | 2 | 12 | 85.7% | 12 | 85.7% | 0 |
| 13. | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 0 | 1 | 1 | 2 | 10 | 73.8% | 14 | 100.0% | 4 |
| | | | | | | | | | | | | | | | | | | | | | | | Total Group Avg. | | 10.77 | 76.9% | 12.56 | 89.7% | 1.79 |

*Note.* Note. Total sample size, n=13. Questions (Q), Pre-Assessment (Pre), Post-Assessment (Pst), Participants (Ps). Points (Pts.)

**Appendix E**

*Assessment Items Comparison*

*Assessment Items Scores*

| | Q1 Which statement below best describes the concerns of (SWC)? | | Q2 Which statement best describes the way to design visual materials that address the need of (SWC)? | | Q 3 Which of these images do you think might require changes for (SWC)? | | Q 4 Choose the area below that can be used to improve visuals for (SWC). | | Q 5 Which definition below best describes contrast? | | Q 6 Choose the image below that you think is the most unsuitable color contrast for (CUD). | | Q 7 Choose the image below that you think is the most suitable color contrast for (CUD). | | Q 8 For each area labeled indicate whether it is suitable /unsuitable color contrast for (SWC). | | Q 9 Which definition below best defines using color to convey information via (CUD)? | | Q 10 Identify the area where color is conveying information and in need of (CUD). | | Q 11 Correctly label the (CUD) corrections needed to improve them for (SWC). | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst | Pre | Pst |
| CA | 13 | 13 | 11 | 13 | 11 | 13 | 4 | 8 | 10 | 12 | 12 | 12 | 11 | 13 | 7 | 11 | 5 | 10 | 8 | 12 | 7 | 8 |
| **%** | **100.0** | **100.0** | **84.6** | **100.0** | **84.6** | **100.0** | **30.8** | **61.5** | **76.9** | **92.3** | **92.3** | **92.3** | **84.6** | **100.0** | **53.8** | **84.6** | **38.5** | **76.9** | **61.5** | **92.3** | **53.8** | **61.5** |
| IA | 0 | 0 | 2 | 0 | 2 | 0 | 9 | 5 | 3 | 1 | 1 | 1 | 2 | 0 | 6 | 2 | 8 | 3 | 5 | 1 | 6 | 5 |
| **%** | **0.0** | **0.0** | **15.4** | **0.0** | **15.4** | **0.0** | **69.2** | **38.5** | **23.1** | **7.7** | **7.7** | **7.7** | **15.4** | **0.0** | **46.2** | **15.4** | **61.5** | **23.1** | **38.5** | **7.7** | **46.2** | **38.5** |

*Note.* Note. Total sample size, n=13. Correct Answer (CA), Incorrect Answer (IA), Students with colorblindness (SWC), Color Universal Design (CUD), Pre-Assessment (Pre), Post-Assessment (Pst),

**Appendix F**
*Module Evaluation*

*Module Evaluation*

| | Strongly/ Somewhat Disagree | Neutral | Strongly/ Somewhat Agree |
|---|---|---|---|
| *Ease of Use* | | | |
| 1. The learning module was easy to use | 0 (0%) | 0 (0%) | 13 (100.0%) |
| 2. Directions were easy to follow | 0 (0%) | 0 (0%) | 13 (100%) |
| *Attention/Engagement* | | | |
| 3. The length of each section was manageable (not too long or too short) | 0 (0%) | 0 (0%) | 13 (100.0%) |
| 4. The use of technology made learning more interesting | 0 (0%) | 2 (15.4%) | 11 (84.6%) |
| *Learning/Quality of Information* | | | |
| 5. The information in the module is useful to me as an educator | 0 (0%) | 1 (7.7%) | 12 (92.3%) |
| 6. This module has prepared me to be a more inclusive educator | 0 (0%) | 1 (7.7%) | 12 (92.3%) |
| *Satisfaction of Experience* | | | |
| 7. I would consider using sharing this module with other educators | 0 (0%) | 0 (0%) | 13 (100.0%) |
| 8. I would consider using a web-based module for learning again in the future | 0 | 0 (0%) | 13 (100.0%) |

*Note.* Note. Total sample size, n=13. Scores based of a Likert 5-point rating scale. *1=Strongly Disagree 2=Somewhat Disagree 3=Neutral 4=Somewhat Agree 5=Strongly Agree*

**Appendix G**
*Participant Feedback*

*Module Evaluation – Optional Feedback*

| *Ps* | Feedback |
|---|---|
| 2 | The module is clear and precise. Very informative and easy to follow. |
| 4 | This was a great experience. It was an eye opener to understanding color blindness. I have family members who are colorblind and I never new these things. The graphics and content are exceptional. Very engaging! |
| 5 | So interactive and applicable examples. This surely pointed me in a direction to be inclusive and aware of what I am doing for my students. Brilliant work! |
| 6 | This course was user friendly and very delightful to use. Thank you for sharing this information! |
| 9 | Information presented in a way that was understandable. I like how you gave immediate feedback to each question so the learner knew if they got the question right or wrong. Also very helpful that you gave visuals to go along with the questions so we knew exactly what you meant. Question 3 above should read "How often do you use...." |
| 10 | The use of technology was perfect and very engaging. Well done!! |
| 11 | Great module and I learned that I knew some of this instinctively and nice to have labels! |
| 13 | There are some repeated questions in pre test you should remove. Overall, nice job. |

*Note*. Participants (Ps)