Are the WEB-pages of the Hungarian Universities Accessible for Students with Color Deficiencies?

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***Abstract*—This article presents the colorimetric testing of the web-sites of the Hungarian universities. The main purpose if this research was to answer our research question, whether the websites of the Hungarian universities are accessible for those students who have some color deficiency problems. Many web-designers not only do not care about accessibility issues, but they do not have any information how they should develop barrier-free web-sites. The overall goal of this study is to determine the most common accessibility problems from the color check point of view and to draw site owners' attention to shortcomings so that they can improve the quality of service of their educational related sites in the future. These case students, who have any color deficiencies, will use the web-sites of the Hungarian universities without problems.**

I. INTRODUCTION

In this paper, we will present the colorimetric testing of web-sites of the Hungarian universities. In this testing, the main subject was to find the most common problems of students with different color deficiencies while they want to find information on the web-sites of the Hungarian universities. Without barrier-free / accessible design they cannot use those web-sites equally.

People with color deficiency can inherit or acquire their vision problems. Special genes that are responsible for proper color vision, it means e.g. cones of red and green cones genes of cells are connected to the X chromosome.

Because of the gender-linked inheritance, this type of impairment is 20 times more prevalent in the male population. Therefore only 0.4–0.5% of Caucasian females and unfortunately approximately 8% of males are "red-green" color-blind. The number of other color deficiency problems is less, like tritanopia which is the so called blue-blindness is only about 0.05% of the Caucasian human beings. Those color vision "illnesses" which are not inherited; they are the causes of other illnesses. Color deficiency problems could come from serious cause of retinal disease, glaucoma or cataracts, etc…) [1]. These color deficiencies are so called acquired disorders.

In this paper, we will present the results of testing and evaluating 64 education-related Web-sites of the Hungarian universities. The following sections will set out the context of the research, its implementation and results and, finally, they will allow verifying the hypotheses proposed. Chapter Two details the literature review, the third looks into the research methods. Chapter Four discusses the results, and the fifth section presents the main conclusions of the research.

II. STATE OF THE ART

A. *Color science*

The harmony of colors and proportions play an essential role in the appearance. Although many tend to neglect these issues, numerous scientific research studies are concerned with this field. All this is based on the color perception of the eye, which, however unconsciously, may have an influence on users' decisions [2].

Many artists and scientists in the last three centuries and these days too [3-7] developed color order systems where they defined rules to establish harmonic sets of colors. These color harmony studies were based on the orderly arrangement of colors in the color order system.

Color harmony (CH) was defined by the second group of authors [6, 8]. It is defined by them, as an interrelationship of colors. The "analogous" and "complementary" color principles are the main parts of those studies. Unfortunately, their concepts are inconsistent in their studies.

They often used the Color Wheel. The Color Wheel was used as a tool for their principles to define some relationships in colors. So, they defined color harmony based on those basic relationships.

Color harmony was defined by Judd and Wyszecki [9]. Their principle was that color harmony is a more universal concept: "when two or more colors seen in neighboring areas produce a pleasing effect, they are said to produce color harmony".

Moreover, no consistency can be found in different principles. Furthermore, the keywords belonging to the color harmony are also not uniform. It is completeness, according to Goethe [6]. Nemcsics [7] and Chevreul [8], defined it as order. Munsell [4] stated it as balance. Many other effects (i.e. age, cultural background) of color harmony feeling have yet to be investigated.

The harmony of hues is also represented in many art and design textbooks with reference to hue circles. "Fig. 1" illustrates four ubiquitous schemes [10].

Color harmony is very important in almost every aspects of our life: color harmony of cosmetics, clothes, color of the surface of buildings, colors of products etc. and last but not least, colorization of web-sites.

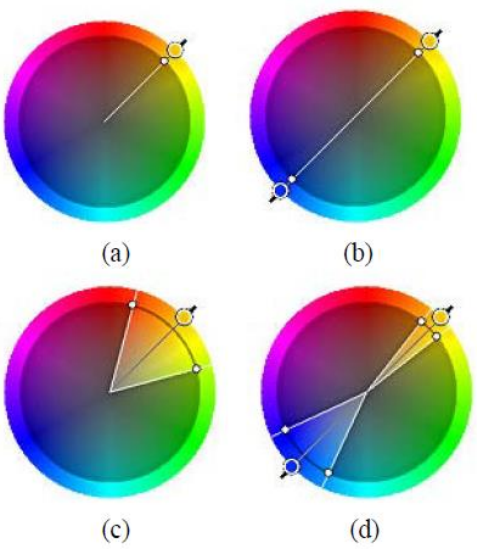

Figure 1. Four typical geometric relationships: monochromatic (a), complementary (b), analogous (c), split complementary (d).

- Fig 1a: If we choose colors from the same or nearly the same hue in the color wheel. It is called monochromatic CH.
- Fig 1b: If we choose colors from the opposite sides in the color wheel. It is called complementary CH.
- Fig 1c: If we choose colors from the same hues in the color wheel. It is called analogous CH.
- Fig 1d: If we choose colors from the opposite sides in the color wheel. But, in this case, there are 3 colors. 2 are from the same side and the 3rd one is from the opposite side of the color wheel. It is called split-complementary CH.

Color harmony is very pleasant for our eyes, more precisely, for our brain.

The viewer is engaged, an inner sense of order is created by it and moreover, the viewer is balanced with the visual experience.

Chaos does not have harmony, if something is inharmonious, we called it chaotic. At one extreme of scenery is a visual experience, if it is very beautiful, the viewer does not engage. Under-stimulating scenery, information will be rejected by us more precisely by our human brain. What is not understandable, our brain cannot organize it, so it will be rejected by our brain. The logical structure is necessary in every visual task. Therefore, it is very important to build up a logical structure in our presentation. A sense of order and visual interest is delivered by color harmony. Under-stimulation is caused by extreme unity and over-stimulation is caused by extreme complexity. Harmony is a dynamic equilibrium [11].

Access to education related websites is of the utmost importance to people all over the world, yet the present research demonstrates that people with color deficiency are often ignored. Many people do not have any idea about color deficiency. They do not think that it could be a serious problem. Approximately 15% of the population has some sort of visual color deficiency. [11].

Unfortunately, the color false design is common. It means that the combinations of background and foreground colors are not appropriate for people with color deficiency. Independently, if the product is a web-page, digital game or other software. People with color deficiency cannot use those products or services. Designers have to choose colors of background, text, and graphics very carefully.

Yes, it is very complicated to design an accessible / barrier-free web-site. It is not a simple issue of red-green or blue-yellow combinations of colors [11]. One of the most important rules or principles in the designing process is to present the information not only by using colors. It means, color as the main part of an information must not to convey the information alone [12].

B. WEB Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) [13]. 2.0 were published on 11 December 2008 and cover a wide range of recommendations for making web content more accessible. It contains 4 principles and 12 guidelines (see the Appendix).

III. METHODS

All 64 URLs of the Hungarian Universities were collected. Three types of investigation were performed:

- Automatic with AChecker [14], AChecker is a free tool that checks single HTML pages for conformance with accessibility standards to ensure the content can be accessed by everyone [14]. AChecker diagnoses known problems, likely problems and potential problems with their levels of conformance based on the WCAG 2.0.
- Semi-automatic test: we used 5 color blindness automatic simulators. They are available freely on the Internet. You can upload your pictures as screenshots of the investigated web-sites [15-17]. We also used downloadable software, ColorOracle [18]. It produces pictures on the observers' display. These pictures are simulated pictures and present how people with different color deficiency see the investigated picture. You can choose deuteranopia-, protanopia-, tritanopia- simulation. The 5th used software was the SEE web-application [19]. This web app. is the best and easiest application for testing color blindness. It demonstrates of a wide scale of visual deficiencies.
- The test phase is concluded with the use of Variantor special glasses [20] and human questionnaire.

All these tests were performed in the time period of February-March 2017.

Our research questions (Q) and hypotheses (H) are:

Q1: Which are the most frequently violated principles based on the error numbers of AChecker results?

H1: Most error numbers originated when web developers violate the first principle.

Q2: Should users who have any color-deficiency be able to use the investigated web-sites the same way as people with no vision impairment (by using as test tools ASP.NET, ETRE, Coblis, ColorOracle, SEE web-application and Variantor special glasses)?

H2: Users who have any colour-deficiency are not able to use the investigated web-sites the same way as people with no vision impairment (by using as test tools ASP.NET, ETRE, Coblis, ColorOracle, SEE web-application and Variantor special glasses)?

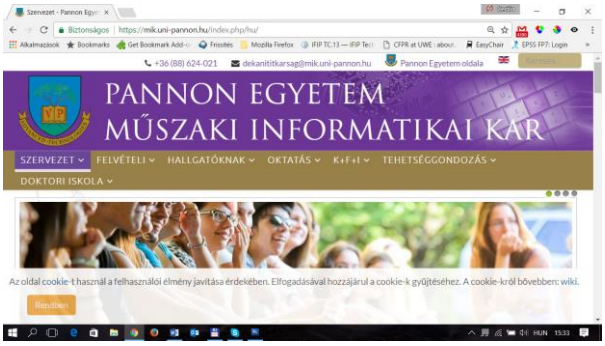

Figure 2. Original WEB-site of Faculty of Information Technology

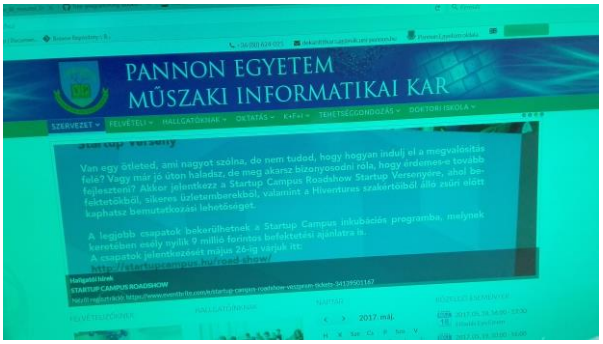

Figure 3. WEB-site vision with Variantor glasses

IV. RESULTS

64 Hungarian university WEB-sites were tested. This section shows not only the statistical data but general observations as well. Table 1 contains the statistical analysis based on those guidelines which are in close connection with the visibility of WEB-sites.

TABLE I.
NUMBER OF ERRORS AND THE VIOLATED GUIDELINES

Guidelines	Levels of con-formance	Type of problems	summa number	largest number	average number
1.1.1 Non-text Content	(Level A)	Known	994	315	15.53
		Likely	21	6	0.33
		Potential	2416	237	37.75
1.3.3 Sensory Characteristics	(Level A)	Known	0	0	0
		Likely	0	0	0
		Potential	104	14	1.63
1.4.1 Use of Color	(Level A)	Known	2	1	0.03
		Likely	0	0	0
		Potential	2871	160	44.86
1.4.4 Resize text	(Level AA)	Known	579	77	9.05
		Likely	0	0	0
		Potential	0	0	0
1.4.6 Contrast (Enhanced)	(Level AAA)	Known	2164	440	33.81
		Likely	0	0	0
		Potential	1466	144	22.91

"Levels of Conformance" are shown in the 2nd column of the Table 1. The Success Criteria/Level of Conformance is very crucial. These guidelines are important issues to solve the problems of people with visual disorder. Without solving these problems, they cannot use the internet. Non-barrier-free Internet causes grater problems for people with visual disorder than for people without visual problems. So, the internet is not accessible hem at all. Therefore WCAG 2.0 contains the mentioned guidelines (se Appendix).

The minimal success criteria or level of conformance is "A". If a web-page conforms to the "Level A", it is the minimal criteria of accessibility.

In spite of the fact that these guidelines help people with visual impairments, these are also useful for mainstream users.

Unfortunately, as Table 1 shows, the 1.1.1 and 1.4.6 guidelines are mostly ignored by WEB-designers although these guidelines are very important from the point of visibility. The general experience is that there were very few WEB-pages which have an aesthetic value, moreover where colors harmonize with each other.

Most WEB-pages are overcrowded, and it is very hard to use them. We do not want to criticize anyone; therefore, the bad examples from our own University were chosen to demonstrate the typical mistakes.

The "Keresés" (search button written with light purple on a light brown background next to the English flag) in the upper right side of Fig. 2 is invisible even for users with a proper vision.

Fig. 4 demonstrates a design mistake: confusing colors. "Információk a 2016-/2017 tavaszi félévi államvizsgáról és diplomavédésről…" purple text in the right side of a black and white crest is very similar as blue color of links. But it is not a link. This light purple is the same purple as the background of the main menu line and the color of submenu text below it.

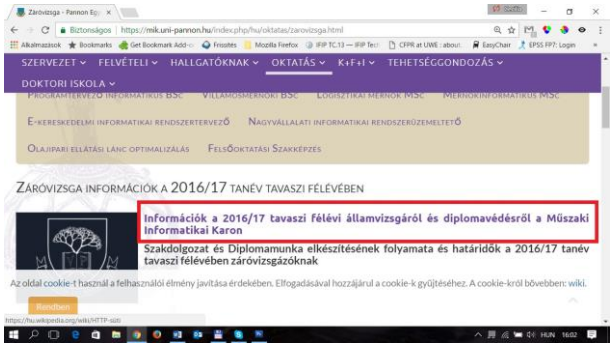

Figure 4. Original WEB-site of the information of the "final exam" site

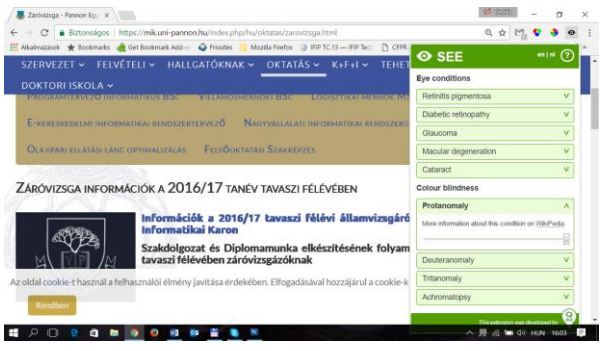

Figure 5. WEB-site of the information of the "final exam" site as it is seen by a color deficient user with protanomaly

Fig 5, Fig 6 and Fig 7 show how confusing it is, that the "Információk a 2016-/2017 tavaszi félévi államvizsgáról és diplomavédésről…" text looks like a link, even though it is not a link.

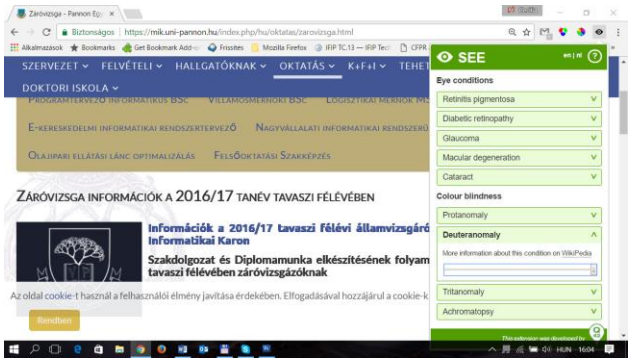

Figure 6. WEB-site of the information of the "final exam" site as it is seen by a color deficient user with deuteranomaly

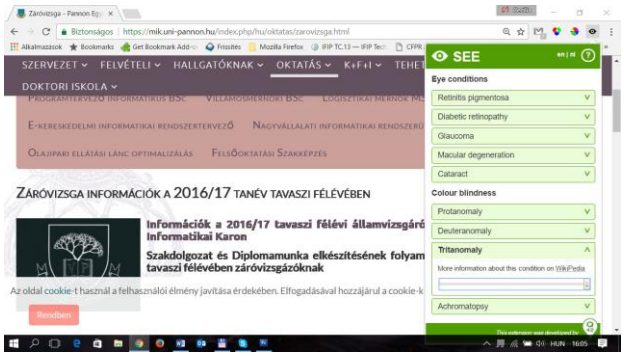

Figure 7. WEB-site of the information of the "final exam" site as it is seen by a color deficient user with tritanomaly

The "A dolgozat formai követelményei" text is a link, but it is cultured with a very pale blue. It is really hard to find that it is a link mainly with proper color vision (Fig 8.) and in the case of tritanomaly (Fig. 11.).

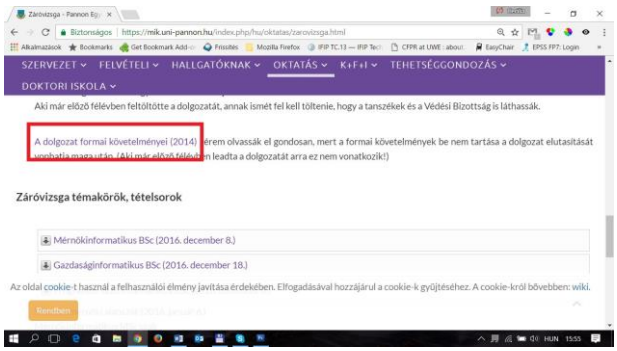

Figure 8. Original WEB-site of the information of the "formal requirements" site

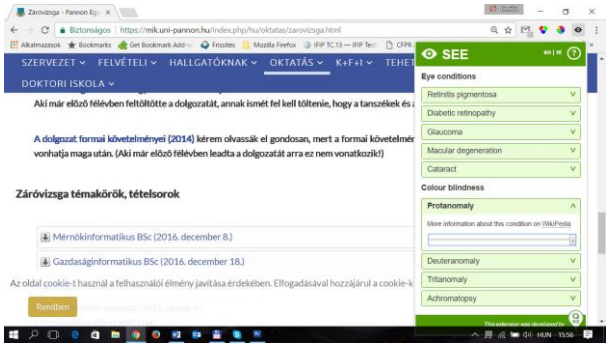

Figure 9. WEB-site of the information of the "formal requirements" site as it is seen by a color deficient user with protanomaly

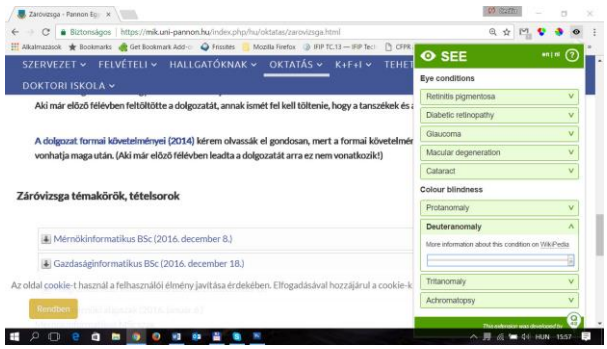

Figure 10. WEB-site of the information of the "formal requirements" site as it is seen by a color deficient user with deuteranomaly

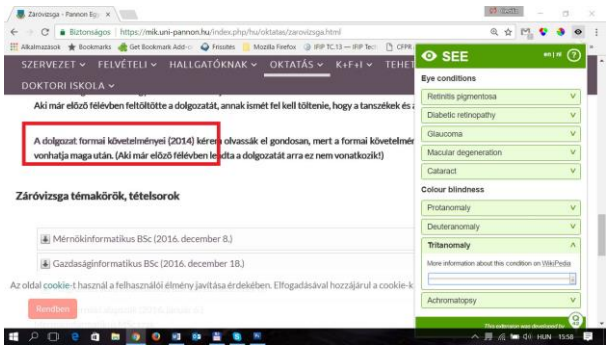

Figure 11. WEB-site of the information of the "formal requirements" site as it is seen by a color deficient user with tritanomaly

The last color confusing example is the WEB page where a red distracting sentence and a pale blue e-mail address are written (Fig. 12). This information is difficult to notice in all cases (Fig. 12-Fig 15.) except for the red highlighted sentence in Fig. 14.

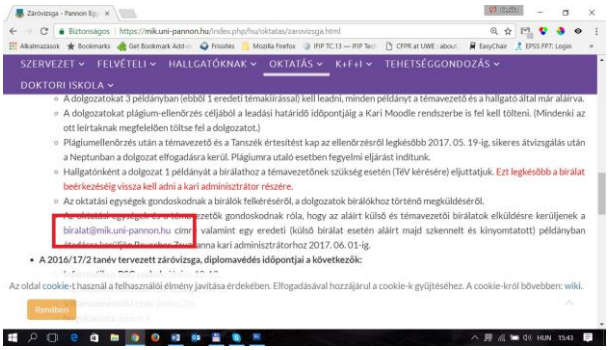

Figure 12. Original WEB-site of the information written with red and very pale blue

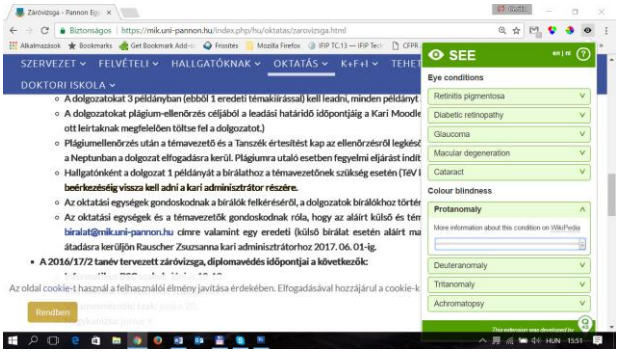

Figure 13. WEB-site of the information written with red and very pale blue as it is seen by a color deficient user with protanomaly

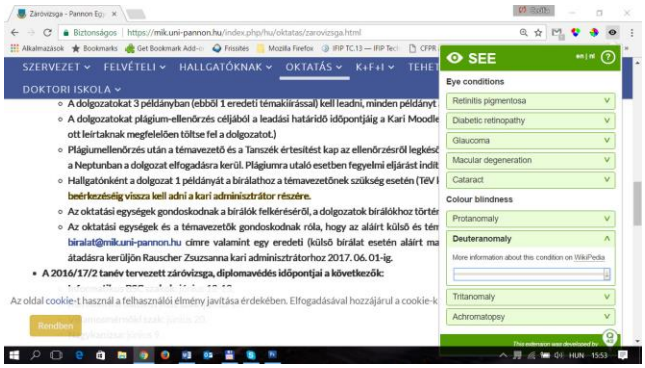

Figure 14. WEB-site of the information written with red and very pale blue written as it is seen by a color deficient user with deuteranomaly

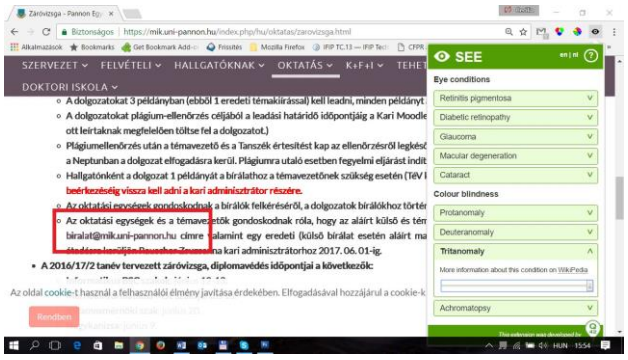

Figure 15. WEB-site of the information written with red and very pale blue as it is seen by a color deficient user with tritanomaly

From the data collected and analyzed from both experts' inspection and automated tools, we can accept or reject our hypotheses. So, we can state that we accept our hypotheses.

Answer to Q1: The most frequently violated success criterions, i.e. 1.1.1 Non-text content, 1.3.3 Sensory Characteristics, 1.4.1 Use of Colour, 1.4.4 Resize text, 1.4.6 Contrast (Enhanced) (see Table 1) which are known problems belong to the Principle 1. So, the H1 is true. Therefore, we formulate thesis 1 as T1.

T1: Most error numbers originated when web developers violated the first principle.

Regarding the answers to question Q2 which is concerned about H2 hypothesis, we can state the following thesis about the color design of the investigated websites: T2.

T2: Users who have any color-deficiency are not able to use the investigated web-sites the same way as people with no vision impairment (evidence is based on using as test tools ASP.NET, ETRE, Coblis, ColorOracle, SEE web-application and Variantor special glasses).

V. Conclusion

We have not found any publications that consider the testing of the color choices used in higher education home pages. This lends credence to our view, that IT engineers and web-site developers do not consider the needs of people with color deficiencies. As a result of our testing, we have reached the conclusion that, unfortunately, not every Hungarian higher education web-site is clearly visible, so students or future students with color deficiency cannot acquire the needed information in the same "easy" way, as the "normal sighted". Our recommendation is for web-designers to create web-sites, where, not only colors provide the visual ques. This means some patterns or a huge contrast could be efficient for ease of visibility in every text, button and link for each web page.

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References

[1] Color-blindness simulator. Accessed: 2017 March 01. URL: http://www.encyclopedia.com/topic/color_blindness.aspx

[2] V. Szucs, C. Sik Lanyi, F. Szabo, P. Csuti, Color-Check in Stroke-Rehabilitation Games, Recent Advances on Using Virtual Reality Technologies for Rehabilitation, by P. M. Sharkey, J. Merrick (Eds.) Nova Science Publisher, 2015, Chapter 18. 7 pages.

[3] J. Itten, *The Art of Color*. Translation by Ernst van Haagen from German "Kunst der Farbe". New York: Van Nostrand Reinhold, 1961.

[4] RVN. Munsell, *A grammar of color*, New York: Reinhold, 1969.

[5] W. Ostwald, *The color primer*. New York: Van Nostrand Reinhold, 1969.

[6] JW. Goethe, *Theory of colors*, Cambridge, MA: MIT Press, 1970.

[7] A. Nemcsics, *Farbenlehre und Farbendynamik*, Budapest: Akadémiai Kiadó, 1993.

[8] ME. Chevreul, *The principles of harmony and contrast of colors*, New York: Van Nostrand Reinhold, 1981.

[9] DB. Judd, G. Wyszecki, *Color in business, science and industry*, 3rd ed. New York: John Wiley, 1975.

[10] S. Westland, K. Laycock, V. Cheung, P. Henry, F. Mahyar, (2007) "Color harmony", *Color: Desing & Creativity*, Vol 1, pp. 1-15, 2007, available at: http://www.colour-journal.org/2007/1/1/07101article.htm#refs (accessed 25 February 2011).

[11] C. Sik Lányi, Choosing effective colors for websites, In: Best J, ed. *Color design theories and application*. Cambridge: Woodhead Publishing Limited, 2012, pp. 600-621

[12] B. Karagol-Ayan, Universal usability in practice, *Color vision confusion*, 2001, available at: URL:http://www.otal.umd.edu/uupractice/color/ Accessed 2016 Feb. 19.

[13] Web Content Accessibility Guidelines 2.0, available at: http://www.w3.org/TR/2008/WD-UNDERSTANDING-WCAG20-20081103/ (accessed September 2016).

[14] AChecker – Web Accessibility Tool, available at URL: https://achecker.ca/checker/index.php Accessed May 2017.

[15] ASP.NET color-blindness simulator. available at: URL: http://aspnetresources.com/tools/colorBlindness Accessed 2015 Feb. 19.

[16] ETRE color-blindness simulator. available at: URL: http://www.etre.com/tools/colourblindsimulator/ Accessed 2015 Feb. 19.

[17] Coblis by Colblindor. available at: URL: http://www.color-blindness.com/coblis-color-blindness-simulator/ Accessed 2015 Feb. 19.

[18] ColorOracle. available at: URL: http://colororacle.org/ Accessed 2015 Feb. 19.

[19] Google Chrome SEE app. available at: URL: https://chrome.google.com/webstore/detail/see/dkihcccbkkakkbpikjmpnbamkgbjfdcn Accessed 2017 Feb. 22.

[20] Variantor – an experience based tool to aid universal design. available at: URL: http://variantor.com Accessed 2015 Feb. 19.

Appendix: WEB Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) [13]. 2.0 were published on 11 December 2008 and cover a wide range of recommendations for making web content more accessible.

The main principles and structure of WCAG 2.0:

- Principles – Top 4 principles.
- Guidelines – 12 guidelines provide the basic goals.
- Success criteria – For each guideline, testable success criteria are provided.
- Levels of conformance – Three levels of conformance are defined: A (lowest), AA, and AAA (highest).

Sufficient and advisory techniques – An informative list of typical mistakes and good-practice techniques is provided. Techniques fall into two categories: those that are sufficient for meeting the success criteria, and those that are advisory.

Common Failures – Describe authoring practices known to cause Web content not to conform to WCAG 2.0

Visibility and Color-related principles and guidelines are Guideline 1.1, Guideline 1.3 and Guideline 1.4.

Principle 1: Perceivable - Information and user interface components must be presentable to users in ways they can perceive.

This means that users must be able to perceive the information being presented (it can't be invisible to all of their senses).

Guideline 1.1 Text Alternatives: Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.

1.1.1 Non-text Content: All non-text content that is presented to the user has a text alternative that serves the equivalent purpose, except for the situations listed below. (Level A)

Guideline 1.3 Adaptable: Create content that can be presented in different ways (for example simpler layout) without losing information or structure.

1.3.3 Sensory Characteristics: Instructions provided for understanding and operating content do not rely solely on sensory characteristics of components such as shape, size, visual location, orientation, or sound. (Level A)

Note: For requirements related to color, refer to Guideline 1.4.

Guideline 1.4 Distinguishable: Make it easier for users to see and hear content including separating foreground from background.

1.4.1 Use of Color: Color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element. (Level A)

Note: This success criterion addresses color perception specifically. Other forms of perception are covered in Guideline 1.3 including programmatic access to color and other visual presentation coding.

1.4.4 Resize text: Except for captions and images of text, text can be resized without assistive technology up to 200 percent without loss of content or functionality. (Level AA)

1.4.6 Contrast (Enhanced): The visual presentation of text and images of text has a contrast ratio of at least 7:1, except for the following: (Level AAA)

Large Text: Large-scale text and images of large-scale text have a contrast ratio of at least 4.5:1;

Incidental: Text or images of text that are part of an inactive user interface component, that are pure decoration, that are not visible to anyone, or that are part of a picture that contains significant other visual content, have no contrast requirement.

Logotypes: that is part of a logo or brand name has no minimum contrast requirement.