CHAPTER SIX

CONCLUSIONS AND FUTURE WORK

6.1 INTRODUCTION

Chapter 6 concludes this research work by highlighting the achievements and contributions in section 6.2. Meanwhile, section 6.3 provides some practical solutions to overcome accessibility challenges. The chapter also investigates some implications for future research in section 6.4.

6.2 ACHIEVEMENTS

The web accessibility discipline has been struggling to make the Web a more convenient environment for disabled people. When accessibility is guaranteed, people with disabilities will be able to use and contribute to the Web more effectively. This is what the present work has endeavored to investigate and realize. The worked tried to fulfill three objectives, which were:

1) 1 To propose a quantitative metric that ranks accessibility barriers based on their severities.
2) To evaluate the metric reliability and validity through empirical studies.
3) To measure the degree of accessibility level improvement for a set of websites after fixing the top severe barriers detected by the metric.

Chapter 2 has reviewed the impact of web accessibility challenges on websites accessibility and discussed the primary problems associated with each challenge.

Standards and guidelines, during website's design and development (user's awareness, motivation and training) and during-evaluation (automated tools and user testing) are identified as the three main challenges. These challenges can lead to non-compliant ways of coding that violates WCAG 2.0. This prevents assistive tools form interpreting the code properly which results in low accessibility level that hinders disabled users interaction with the Web. Two main approaches where identified to increase the accessibility of websites, namely prevention actions and correction actions. The prevention actions aim to decrease the possibility of web accessibility barriers while designing a website. Meanwhile, the correction actions fix the barriers once occurred. This work focuses on the correction actions since they can provide solutions even for Web developers with limited experience in accessibility issues. Many efforts were made to determine the most common barriers that threaten the accessibility so the Web developers can fix them to increase the accessibility of websites as well as avoid them in the future. However, the majority of the correction approaches are based on the evaluator experience and limited surveys and they lack of a clear mathematical model. Thus, Chapter 2 has suggested the need for a mathematical based quantitative metric that ranks accessibility barriers based on their severities and influence on the accessibility issue.

Chapter 3 has discussed the research design which includes the process for validating WABS metric quality and covered the study's hypotheses' development and the experiments used to test these hypotheses. Moreover, the process for measuring the degree of accessibility level improvement after removing highly ranked barrier identified by WABS is discussed as well.

Chapter 4 has tried to meet the first objective by designing a quantitative metric that meets the requirements as a measurement for scientific research. The metric formulation is inspired by the vector space model principles. In order to achieve the second objective, five hypotheses were formulated to check the metric quality. Accordingly, Chapter 5 has conducted four empirical studies to validate the hypotheses in order to check the metric validity, reliability and sensitivity. Furthermore, the third objective of this research work was fulfilled by measuring the degree of improvement in accessibility level for a dataset of websites after removing the most five severe barriers which were identified by WABS.

The main contributions of this research work are described and enumerated as follows:

1) *Developing a Web Accessibility Metric that Measures Barriers' Severity*

This work has argued that unveiling the most severe barriers and fix them accordingly will increase the accessibility level of websites. This has been achieved by developing a Web Accessibility Barrier Severity (WABS) quantitative metric that ranks barriers based on their influence on limiting web accessibility. WABS metric is basically formed to meet the requirement of building a good metric as suggested by (Zeng, 2004; Vigo et al., 2007). Furthermore, it utilizes some parameters used by metrics proposed by (Zeng, 2004) such as barrier frequency, priority level that has been violated and the number of test cases. The metric took into consideration the following measurements: (1) The importance of the barrier to other barriers that violate the same priority level; (2) The importance of the barrier to the webpage; and (3) The importance of the barrier to all the other barriers in the whole dataset (all websites). The metric formulation is inspired by the vector space model in terms of barriers weighting and ranking.

Two principals were used from vector space model, namely the extension of Pythagorean Theorem (Weisstein, 2014), which is used to measure barrier length in different context (this principle covers the first and third measurements). The second principle is TF-IDF (Sparck Jones, 1972) which was adjusted to meet the second measurement.

2) Validating WABS Metric Quality.

Five hypotheses were made to check the metric quality in terms of validity, reliability and sensitivity. The hypotheses address barriers' weights regarding differences between priority levels [H1], differences within the same priority level [H2], automated tool being used [H3], testing the sample over time [H4] and testing with different sample [H5]. Four experiments were conducted to validate these hypotheses. Descriptive and inferential statistics were used to analyze experiments' results. The results of each experiment were further discussed to test the corresponding hypotheses. Experiments' analysis showed insignificant change in barriers' weight when different tools, time span and sample are used, thus all the hypotheses are rejected. Hence, WABS meets the properties which a valid and reliable metric should have. Web developers can utilize WABS metric to highlight the most severe barriers then fix them later to increase the accessibility level of their websites.

3) Measuring The Degree Of Web Accessibility Level Improvement After Fixing Highly Severe Barriers

The reports generated by A-Checker tool when evaluating Malaysian websites were utilized from the first experiment. Based on A-Checker results the accessibility level was measured for each website using Zeng's modified metric, formula (3.3). Then, WABS metric calculated barriers severity for the Malaysian dataset and rank the barriers

accordingly. Following, the top five severe barriers detected by WABS were removed from the evaluated dataset which are: (1.1.1, 1.4.4, 1.3.1, 1.4.6, 2.1.1). Once the top ranked severe barriers are removed, the accessibility level of the websites was measured again using formula (3.3). Then the accessibility level of websites was compared statistically before and after removing highly ranked barriers. Paired samples t-test elicited statistically significant improvement of accessibility level after removing the five severe barriers ($t = 8.467$, $p \approx 0.001 < 0.05 = \alpha$).

6.3 RECOMMENDATIONS

In this section, five practical and applicable solutions based on the analysis of accessibility challenges in this research are introduced to overcome accessibility obstacles. They are presented as follows:

1) *Enforcing Accessibility Legislation*

Widespread recognition of the contribution of ICT, and the Web in particular, towards promoting social inclusion and reducing discrimination against people with disabilities is reflected in legislations and policies across the world. Awareness of the nature and implication of legislations and policies regarding web accessibility in different countries is important to guide organizational web accessibility policy. This can be made possible by enacting their own legal standards or legislation rather than following voluntary guidelines. A total collaboration between Web team, stakeholders, individual industries and various states is essential to ensure equality and guarantee all human beings' rights to use the Web without discrimination. Individual industries and countries need to diligently enhance the enforcement of accessibility legislation. In addition, a project manager has

the responsibility to make his Web team adhere to accessibility principles. Without a managerial impact on accessibility, it is quite normal for the Web team to ignore the accessibility issue or to pretend they have taken care of it (Pereira et al., 2014).

2) *Creating New Web Accessibility Position*

One possible viable solution to increase accessibility motivation is to create a new position related to accessibility, e.g. accessibility specialist/expert. This expert can interact with the project team and senior management to make a positive impact on both the community (potential customers) and the organization. In fact, this expert can be a Web developer, a quality assurance engineer, or a project manager who takes accessibility training courses and participates in workshops. On the other hand, organizations should start sponsoring workshops for their employees and allocate appropriate funding to support accessibility in their reserved budget.

3) *Providing Applicable and Usable Guidelines*

It is not the case that WCAG 2.0 is not good enough; it will be more useful if the WAI structures the guidelines via job roles that each guideline impacts (i.e. SCs will be easier to read if each Web team member knows which of them he/she needs to deal with). WAI's assignment of levels to WCAG 2.0 SCs considers the needs of disabled users; however, it will be very helpful if they give an idea of the disability type that would benefit from conforming to each criterion. Moreover, WAI has to be transparent regarding the cost of implementing each guideline. Reasonable measures should include identification of the costs of conforming to accessibility guidelines. Instead of emphasizing the need for perfection, guidelines should be flexible enough to encourage Web developers to follow them. This, indeed, will contribute in minimizing the difficulty

in both guidelines' structure and presentation. Meanwhile, Web developers should not get frustrated by WAI restricted rules. They should aim for continuous improvement of accessibility over time.

4) *Changing the Web Team Mind-Set*

To meet end-users' needs, Web developers are required to feel as end-users in the accessibility issue. In other words, programmers have to test the website with disabled people or at least use a standardized accessibility testing tool, so that when web developers want to write/change the website's source code, there is a need to change the developers' mind-set to include accessibility. Many Web developers do not know the importance of making a website accessible and how this will help disabled people to interact with the Web. Moreover, we must change the programmer's perspective regarding the way they code rather than simply asking for a list of changes. Thus, there is a real need to move away from a problem-based approach towards a design principle approach for web accessibility. The whole Web team should be inclusive from the beginning when designing an accessible website. Private and public sectors should stress that accessibility is an important indicator of website quality and without it; the quality of the website will remain low. In addition, emphasizing the importance of accessibility guidelines should start early in Web development education. This should take place at the entry level of Web development courses. Training and exposing IT professionals and Web engineers to accessibility guidelines at an early stage increases their awareness and improves their programming attitudes toward this vital issue. Why wait to expose IT students to accessibility until they take senior computing courses when we can make them

aware of it earlier? By making accessibility the focus of an introductory level computer science course, we can increase accessibility awareness among IT students.

5) *Deploying WABS Metric*

WCAG 2.0 emphasizes the need for perfection scores on all SCs for a certain level in order to get the level conformance logo, which makes it impossible for some websites to achieve any acceptable level of conformance, especially for those websites who are run by people with little experience and training. However, Web developers should not get frustrated by this. They should aim for continuous improvement in accessibility over time. There is an imminent need for real collaboration between Web developers and evaluators. Web evaluators can utilize WABS metric to highlight the most severe barriers that affect the accessibility of an intended region. Then, they can motivate Web developers to focus on studying success criteria that are related to most severe barriers and correct them. By time, Web developers become more familiar with web accessibility guidelines and will play an important role in making the Web a more convenient environment for people with disabilities.

6.4 IMPLICATIONS FOR FUTURE RESEARCH

This section presents the implications of the study and makes suggestions for future research.

6.4.1 Applying the Metric to the Results of Different Evaluation Methods

WABS metric in this work has utilized automated tools results; it would be useful to apply other different accessibility evaluation methods (AEM) results. Real user testing, screening techniques and subjective assessments could yield different results since their

validity, efficiency and reliability differ. The validity and reliability of WABS results depends on the quality of results produced by AEM. Moreover, user testing technique may fail to yield consistent results when performed by different evaluators. The evaluator's effect comes to light when different persons evaluating the same website detect different types and numbers of accessibility barriers. The evaluator's effect has been extensively studied in the usability field. Unfortunately, this is not the case for web accessibility evaluation methods (Yesilada et al., 2009). A future study could identify the effectiveness and reliability of results produced by evaluators with different levels of expertise. Later, the results of expert assessment could be applied to WABS to enhance its results since assessments made by experts are by far more reliable than automatic assessment (Brajnik et al., 2010).

6.4.2 Automating WABS Metric

The existence of automated tools has simplified the process of accessibility evaluation. WABS metric has utilized automated tools' results to find out the number and type of each barrier. However, when conducting large scale evaluations, collecting and aggregating the results could be time consuming. Evaluating thousands of websites then extracting each barrier type and frequency in each website will take a considerable amount of time and can be inefficient. Unfortunately, available automated tools allow only for individual evaluation of websites. Developing a system that can run massive evaluation requests could be promising since many evaluators seek to conduct large scale studies. For future work, a researcher can build an automated tool that handles an immense number of evaluation requests. At another level, the researcher can build a program that utilizes existent tools results. However, system performance could be an

issue, since sending synchronous evaluation requests to a tool could degrade the tool's performance, resulting in time out error.

6.4.3 Enhancing the Collaboration between Web Evaluators and Developers

As mentioned earlier, a true collaboration between Web evaluators and developers will have a positive influence on improving the accessibility levels of websites. However, good communication channels should be established between Web evaluators and developers to make collaboration between them more efficient. Web evaluators need means to inform other developers of the accessibility condition and barriers ranking in websites that target audience in a specific region.

Making barriers' ranking over time public (for an intended region); can help in reaching a large spectrum of Web developers and spread awareness among them. For a future study, researchers can investigate the most efficient way of collaboration and find out whether it can be achieved by developing a website that announces metric results or via a system that broadcasts the results to Web developers.

6.4.4 Improving Mobile Accessibility

Mobile devices are widely used, even in developing countries, to access the Web. Users can access internet through smart phones, either by using mobile websites or through applications. According to the World Bank (2015), Malaysia is leading most Southeast Asia countries and even the United States with 140% mobile penetration. However, mobile devices including smart phones and tablets have some limitations that hinder interaction with the Web. Mobile accessibility aims at making websites and applications more accessible to people with impairments when they are using mobile devices. Many

Web designers and mobile application developers are not aware of the existence of guidelines that specify how Web content should be delivered to mobile devices for mobile friendly content (e.g. WCAG and Mobile Web Best Practices (MWBP)). A study by Abuaddous et al. (2013) indicated the lack of website accessibility for public higher institutions in Malaysia over the years. Thus, a future study can evaluate the accessibility of Malaysian public institutions' mobile websites.