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**“E-book accessibility”**

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## Summary

Accessibility play a vital role in every human being life to access any type of digital information. Every person has a right to access digital information properly without any problems. Unfortunately, people with some disability is sometime unable to access the e-books due to inaccessibility of e-books. An accessible reading is very important, and in this research of “E-book accessibility” different e-book was tested to find out the accessibility problems for the blind people and people with low vision. The aim of the research is to find out the possible e-book accessibility issues and provide recommendations and suggestions to the developers and publishers against these accessibility’s issues. Three main e-book accessibility issues were found after testing the different e-books and that was “inaccessible e-book document”, “lack of assistive technology in e-reader” and “lack of accessible tools in e-readers”.

Research follow the visually impaired user (blind people and people with low vision) as a target group of the research, because background study showed that number of blind people and people with low vision ratio is more than the other people with disability. Since, there is no specific accessibility guidelines are designed for e-book document, so WCAG 2.0 Web Content Accessibility Guidelines and techniques are used in the research to check the accessibility in different e-books. Moreover, UAAG 2.0 User Agent Accessibility Guidelines were used in research to check, whether accessible tools and assistive technology was helpful for the blind people and low vision people while reading e-books.

Research followed two parts. In the first part, possible e-book accessibility problems and e-book accessibility benefits was discussed. In the second part, different e-books were tested to find out the accessibility problems for the blind people and people with low vision. Findings of the research was accessibility issues (e- book document is inaccessible lack of assistive technology and lack of accessible tools). To achieve the goal of the research, research methods automated testing and manual testing were used. User testing plan was discussed to find out more

accessibility's problems. Finding of the research method was again the possible accessibility problems in e-books.

After testing, results (accessibility problems) comparison was conducted with the WCAG 2.0 Web Content Accessibility Guidelines and UAAG 2.0 User Agent Accessibility Guidelines. How accessibility guidelines (WCAG 2.0 and UAAG 2.0) improve the accessibility in e-books. These guidelines also help the publisher to make it sure whether the e-book is accessible before making it available on e-shop and every e-book content is readable by assistive technology and accessible tools for the blind people and people with low vision. After, recommendation and suggestion of an accessible e-book is provided my me with the help of WCAG 2.0 web content accessibility guidelines and technique to the publisher and programmer for the e-book document and accessible tools, assistive technology for the e-readers.

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# 1. Introduction

E-books are the electronic version of the printed books. E-books are readable through electronic devices e-readers and e-book applications. E-reader is a reading device that is used to read the e-books. There is a variety of e-readers are available in the market to read the e-books like Kindle, Nook, iPad and many other devices. People can purchase the e-readers depending upon their budget and reader cost (Librarians, Leverkus, and Acedo, 2013).

According to Librarians, Leverkus, and Acedo (2013)

*“The new Oxford American Dictionary defines “e-book “as” an electronic version of a printed book that can be read on a computer or handled device designed specifically for this purpose”” (What is an e-book, p.1, para 2).*

Before the e-books, reading through printed books seems to be very difficult for the people with disability. For instance, reading through printed books is sometimes impossible for the blind people, people with low vision, people with dyslexia, people with physical disabilities and other screen reader users.

The printed books (in the form of hard copy) is now converted to the electronic books (in the form of soft copy) through some computer program. There is a proper cycle to convert printed books into the electronic books. Every printed book is readable after converting it into the electronic book by everyone including people with disability with the help of accessible features. On the other hand, printed books are inaccessible especially for visual impaired users (blind people and people with low vision). For instance, blind people do not understand the concept of visual data (images, shapes etc.) in printed books and people with low vision have no zoom option, color contrast etc. in printed book. Through assistive technology and accessible tools (magnification, alternative text of images, change font style option, color contrast option and many other accessibility features) reading becoming easier for blind people and people with low vision as well as other people with disability. They can adjust their text according to their need, images can be readable by their alternative text provided by the author in the e-book document.

Assistive technology provided by developer in e-reader are available for the people with disability that help them in reading efficiently and without any difficulties (Cavanaugh, 2006).

McNaught and Alexander (2014) states print disability as

*“The term print disability refers to any disability that hinders an individual’s ability to access hard-copy printed text. It is more than visual difficulty and includes those who have difficulty decoding printed text – for example dyslexic people. Equally, spinal injury or involuntary muscle spasms may hinder someone from physically holding a book.”* (“What do we mean by accessibility and what are the issues?”, para 3).

E-book accessibility is defined by Mason (2012) in her article. She said that e-book accessibility is a very interesting topic, and now a day, it is becoming more popular topic. She defines e-book accessibility is to read the e-books without the interfering of third party. In other words, read the books independently. In addition, Mason (2012) describes that e-books are very helpful for both visually impaired and users with print disability, because of its interactive features and properties and it will be only possible, if the reading device and e-book applications supported accessibility features for the e-books. Accessibility features helps the people with disability to read the e-book independently. Accessibility features are assistive technology and accessible tools.

## 1.1 Accessibility features

Accessible features are the assistive technology and accessible tools. Assistive technology is a software that helps the people with some disability to use the system without any difficulty. These are the special tools, systems and programs that are designed to help the people with disability. By using assistive technologies and accessible tools, most of the problems related to accessibility are removed in the life of people with disability. People with disability can use the digital media by using assistive technology and accessible tools (Ohnabe, Kubo, Collins, & Cooper, 2011). For instance, screen reader assistive technology helps the blind people and other screen

reader users to read the screen aloud and make it possible for them to use the digital media (e-book reading) independently. Similarly, accessible tools contain zoom in, zoom out, font resize, change font style, foreground color and background color and other accessible options that help the people with low vision and people with some other disability to make the reading possible for them.

Accessibility play an important role in e-book reading. Accessibility is the only thing that help the people with disability to access the attractive features of the e-book and other digital media (websites, digital document etc.) with the help of accessibility features. Accessibility features are developed by the developer and programmers to make the e-books, websites and other digital document accessible to everyone. It is the responsibility of the developer and the programmer to develop such type of assistive technology and accessible tools for everyone including the people with disability that help them in e-books reading as well other digital document and websites. Attractive features are the images, videos, audio etc. and through assistive technology and accessible tools, people with disability enjoy these attractive features in the e-books, websites and other digital document ("What is accessibility?", n.d.).

According to Kettler, Elliott, Beddow, & Kurz (2018)

*"Accessibility defined as the extent to which a product, environment, or system eliminates barriers and permits equal use of components and services for a diverse population of individuals"* ("Accessibility Instruction and Testing Today", p.1, para 1).

Moreover, accessibility is a feature that is treated differently according to developing needs and demands, and there is no specific agreement of accessibility not even in ISO standardization community, but accessibility is used almost every frameworks and situations (Persson, Åhman, Yngling, & Gulliksen, 2014).

Hence, from the above discussions it seems that, accessibility helps the people and the people with some disability to use any type of product, software without any difficulty, and e-book

accessibility helps the people with disability to read the e-book content with the help of accessible features of e-readers and e-book applications. Accessibility creates the equal opportunity for every people including people with some disability in term of media usage. Accessibility is very important and essential to people while reading digital document. Accessibility cannot be achieved without assistive technology and accessible tools (screen readers, zoom in, zoom out, background, foreground etc.).

E-book content are heading, title, table of contents, e-book language, paragraph, formatting of e-book document, visual presentation (images, tables, graphs, tables, diagrams etc.) of data, non-visual presentation of data (text), video data, audio data and many other contents.

In addition, e-book accessibility is a connection between the readers and their needs. For instance, every reader wish is to purchase such type of book that fulfil their reading needs according to their need and preferences. For example, e-book document must be accessible, and all the e-book content is designed according to accessibility guidelines for the people with disabilities. Further, accessibility features of e-readers and e-book applications are according to e-book content. Both e-book document and accessibility features are correspondence to each other. For instance, headings in the e-book document is design according to accessibility guidelines and screen reader (assistive technology of e-reader) navigate the e-book content through accessible headings. Different assistive technology/accessible tools are available like screen readers, color contrast, text to speech, alternative text and many more features helped them in reading e-books (McNaught & Alexander, 2014).

## 1.2 What is necessary in an accessible e-book?

Firstly, an accessible e-book document that is designed according to accessibility guidelines for the people including people with disabilities. Secondly, assistive technology and accessible tools provided by the developers and the writers so that accessibility can be achieved in e-books.

Assistive technology is a software that aided the persons with disability to navigate the book content easily. Assistive technology and accessible tool should be provided by the e-book retailer who is responsible for accepting and converting the authors work in digital format as well as make it available on e-book shop (Gunn, 2016).

### 1.3 Problem statement

The problem identified by conducting background study in e-book accessibility research is “inaccessible e-book document” and lack of “assistive technology and accessible tools” in e-readers. E-book document is not designed according to the accessibility guidelines for the people with disability. Moreover, e-readers have very less accessibility features e.g. e-readers accessible tools and assistive technology for the people with low vision and blind people that creates inaccessibility in e-books reading. In other words, e-readers are not design according to the accessibility guidelines for the people with disabilities.

According to Gunn (2016) retailers are not providing the assistive technology and accessible tools properly in e-readers that are matching with e-book document or e-book content before making it available on e-book shop. E-book document is not fully formatted and designed according to the accessibility guidelines (WCAG 2.0) and e-readers do not fully support accessibility features (accessible tools and assistive technology) to the people with disability. E-book content is heading, sub headings, image attribute, links, hyperlinks, paragraph, table of contents and many other contents of e-book document. The e-book content must be accessible and readable with e-reader accessible tools and assistive technology to the people with low vision and blind people. In other words, e-reader accessible tools and assistive technology help the blind people and people with low vision to read the e-books and achieve e-book accessibility for them. If user is unable to read the e-book through e-reader accessible tools and assistive technology, then either the e-book document is inaccessible, or the e-reader assistive technology and accessible tools are inaccessible. Mostly, e-readers are still containing such issues (lack of accessible tools or

assistive technology) that doesn't promote e-book accessibility like Kindle and Nook press (e-readers) doesn't support image accessibility. They don't read the alternative text in the image. Apple iBooks (e-reader) have some layout problem and readers are unable to adjust the text and some presentations options (Gunn, 2016).

Alternative text of the images describes the image in the form of text for the screen reader users including the blind people. E-reader assistive technology (screen reader) read the alternative text aloud for the blind people and other screen reader users, so that people with disability can understand the images by listening the alternative text. Unfortunately, some images found in e-book document are without alternative text and assistive technology (screen readers) are unable to explain the images without alternative text to the screen reader users and blind people. Moreover, Web Content accessibility guidelines explains that if the document contains the image then it must be described by the alternative text for the screen reader users (Bigham, Lin, & Savage, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008).

According to Bigham, Kaminsky, Ladner, Danielsson, & Hempton (2006) every image should have an alternative text. If there is an image on web without alternative text it has no meaning for the blind people and screen reader users. Similarly, if e-books document has images then provide alternative text against every image in the e-book to achieve the accessibility in e-books for the people with disability.

Technology is getting advanced rapidly, but people with low vision and blind people are still struggling due to inaccessibility's in e-readers and in e-book. For instance, many e-reader applications don't support animated data, flashing data, video related data, images, shapes and many other e-book contents in the e-book document. E-reader assistive technology (screen reader) ignored the visual data (diagram, shapes, graphs, animated data, flashing data etc.), video data in the e-book document. There are two reason of inaccessibility in e-books, one is e-book content is highly inaccessible and is not designed according to accessibility guidelines and techniques, second reason is e-reader assistive technology and accessible tools is not designed

according to user agent accessibility guidelines and techniques. In case, if e-book document is inaccessible then e-reader assistive technology provides some metadata against the inaccessible content (diagram, shapes, graphs, animated data, flashing data etc.) to the blind people and other screen reader users as well as other people with disability. Hence, blind people and other screen reader users are facing difficulties when screen readers are unable to support the e-learning and e-books documents (Armstrong & Murray, 2007).

Moreover (Maatta & Bonnici, 2014), compared three e-reader's accessibility features. They found that two e-readers doesn't meet the accessibility features (assistive technology and accessible tools) for the blind people and people with low vision. Inaccessible e-readers are amazon kindle fire and NOOK tablet. They are highly inaccessible for blind people and people with low vision, because they are not fully supported text-to-speech, large text and zoom accessibility features for the blind people and low vision people. That is a very major drawback for the visual impaired users (blind people and people with low vision). People with low vision face many difficulties without the zoom accessibility feature in e-readers.

Text to Speech (TTS) is the software that reads the text aloud and help the blind people and other screen reader users to read the e-book document. Similarly, screen reader is the software that reads the screen for the people who are unable to read the screen by themselves. Screen reader and text to speech both are the software called Assistive Technology (AT). Voice Over is the software that reads the screen aloud and build in Apple products to achieve the accessibility for the people with disability especially for the screen reader users (blind people) (Schlünz, et al., 2017).

#### 1.4 Research question

1. What are the specific problems and characteristics of e-book document and e-reader in term of accessibility for blind and people with low vision?
2. How can the WCAG 2.0 and UAAG 2.0 accessibility guidelines improve the accessibility of

e-books and e-readers?

Problems and benefits related to e-book accessibility will be identified in literature survey. What type of accessibility problems and benefits related to e-book document design and e-reader accessibility features for the blind people and people with low vision have will be discussed in the literature review to answer the research question one? Accessible e-book design is something whether the e-book document or e-book content is designed according to accessibility guidelines and techniques. For instance, e-book title, table of contents, headings, sub headings, images, videos, audio, and other content are usable for everyone including people with disability. Accessible features are assistive technology and accessible tools in e-readers. For instance, what type of accessibility problems and accessibility advantages/benefits visually impaired users (blind people and people with low vision) tackled during the use of some accessible features (assistive technology and accessible tools) in e-readers.

Problems will be discussed according to Web Content Accessibility Guidelines (WCAG 2.0) and User Agent Accessibility Guideline (UAAG 2.0). Different methods will also be used in the research to find out more accessibility problems in e-books. After finding the problems the next step will be to compare the possible problems with accessibility guidelines and techniques. Problems associated with e-book document will be discussed according to WCAG 2.0 accessibility guidelines and techniques. Problems associated with accessibility features (assistive technology and accessible tools) will be discussed according to the user agent accessibility guidelines. The problem discussion according to accessibility guidelines and how these accessibility guidelines improve the accessibility in the e-books and e-readers will be the answer of research question two. After the answers of both research questions, accessibility points of an accessible e-book document will be recommended to the publisher with the help of WCAG 2.0 accessibility guidelines and technique by the author of “e-book accessibility” researcher.



## 1.5 Target group and aim of the research

According to Dursin (2012), visually impaired users are low vision and blind people. People with low vision are those who have a very low vision and used some accessibility features (assistive technology and accessible tools) to read digital data (e-book). Blind people are those who cannot able to see the things and by using assistive technology they manage the digital data. For instance, blind people use screen reader software to read the screen aloud and people with low vision use magnification or other accessible tools according to their need. The visually impaired user's (blind people and low vision people) ratio is increasing day by day, who are aided by the accessibility features (assistive technology and accessible tools) while reading e-books. When accessible tools and assistive technology are very less then it creates inaccessibility and bad impacts on both blind and people with low vision. They lost their self-confidence as well as many other harmful social impacts happen on their life. Equal opportunity between people and people with disability does not fulfilled when accessibility feature is inadequate and e-book document content are inaccessible.

“Department of social welfare statistics in Malaysia about visually impaired users states that the visually impaired users increased day by day and ratio of visually impaired users are 26,155 in 2009 and 27,582 in 2010, and this ratio is increasing rapidly. Number of visually impaired users are 285 million and 39 are blind and rest of 245 million are low vision people” (Mothiravally, Ang, Baloch, Kulampallil & Geetha, 2014).

Research will focus on visually impaired users (blind people and people with low vision) because the blind and people with low vision faces inaccessibility in e-books. Accessibility features (assistive technology and accessible tools) are not meet their reading requirements in e-books for them. In other words, they are not satisfied with assistive technology and accessible tools provided in e-readers by the developers. E-book document is not created according to accessibility guidelines. It is also noticed by literature review; the blind people and people with low vision have many problems with inaccessible e-book document, and accessibility features

don't meet their requirement of reading. Hence, target group is visually impaired users (people with low vision and blind people).

Findings of this project will be the possible accessibility problems in e-books, and how the accessibility is improved in e-books with the help of WCAG 2.0 web content accessibility guidelines and techniques. Moreover, how UAAG 2.0 user agent accessibility guidelines improves the accessibility features (assistive technology and accessible tools) in e-readers. After the comparison of accessibility problems with the WCAG 2.0 and UAAG 2.0, suggestion and recommendation of an accessible e-book and accessibility features (assistive technology or accessible tools) is provided by me that help the publisher to achieve the accessibility in e-books.

## 1.6 Project plan

In project plan, three phases literature review, testing, discussion with accessibility guidelines will be conducted. Literature review will be the first phase of master thesis e-book accessibility. In literature review part, benefits and problems of e-book accessibility will be discussed. Possible problems and benefits in terms of e-book document, assistive technology, accessible tools, e-book formats, printed book vs e-book and many other accessible features will be discussed in this phase. The finding of literature review will be the e-book accessibility benefits and problems.

Testing will be the second phase of master thesis e-book accessibility. Methods of testing will be the automated testing and manual testing and user testing. Test cases will be written for manual testing and automated tools will be used in automated testing. Moreover, user testing plan will be discussed in the research e-book accessibility. In user testing, testing with the real users will not be possible due to the time constraints and findings of the real users, but plan of user testing will be discussed in this research. Questionnaires for the people with low vision and interview question with the blind people will be designed to find out more e-book accessibility problems by conducting the user testing in this research. The findings of the methods (automated testing

and manual testing) will be the accessibility problems for the blind people and people with low vision.

In the third phase of master thesis problems will be discussed according to the WCAG 2.0 and UAAG 2.0 accessibility guidelines and techniques. How WCAG 2.0 improves the accessibility in e-books by providing the accessibility guidelines and techniques with respect to each problem identified after the testing. How UAAG 2.0 improves the accessible features in e-readers with respect to each problem identified after testing.

In the end, some recommendation will be provided to the publisher to make the e-book accessible before making it available to e-shop with respect to WCAG 2.0 accessibility guidelines and technique.

Following are the project plan in the form of Gantt chart, that shows the project phases according to start time and time of each phase.

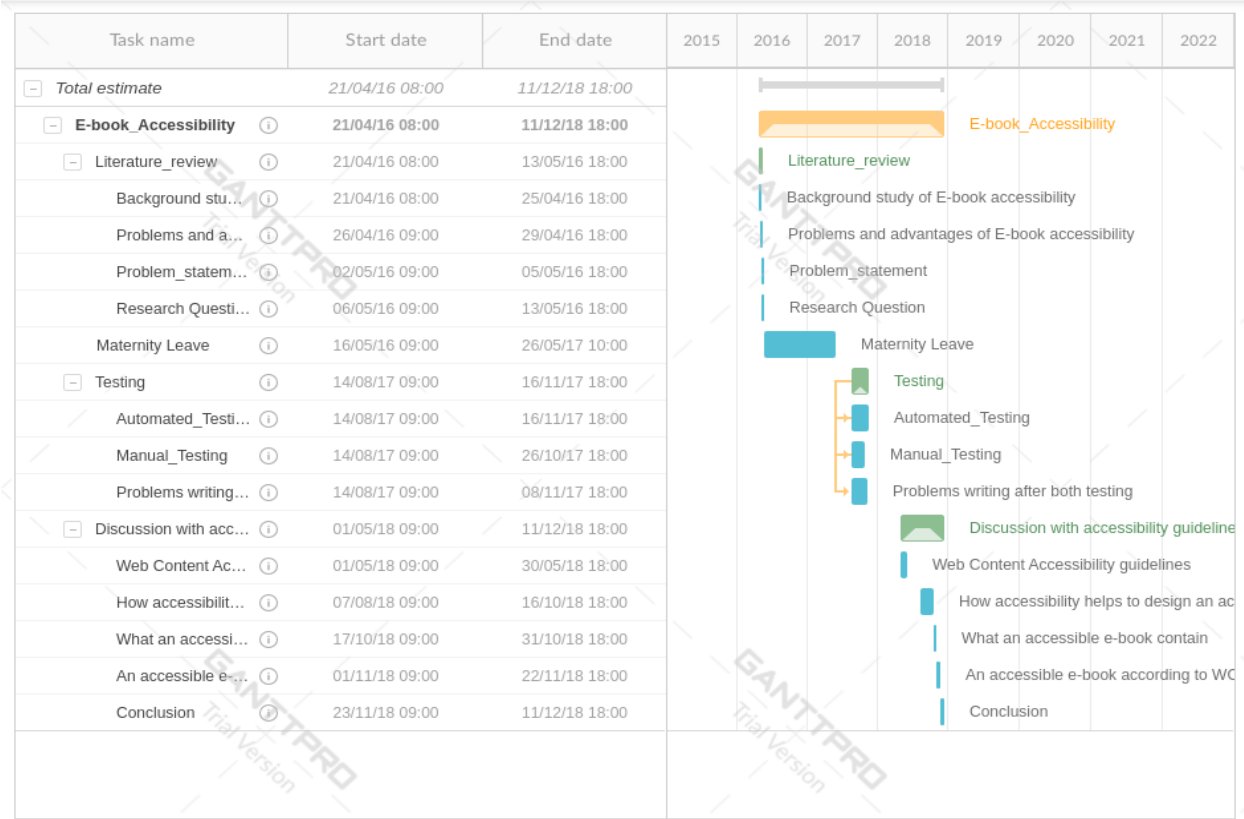


Figure 1.1 Project Plan

## 1.7 Project phases

Following are the different phases will be conducted in e-book accessibility research to fulfill the research goal.

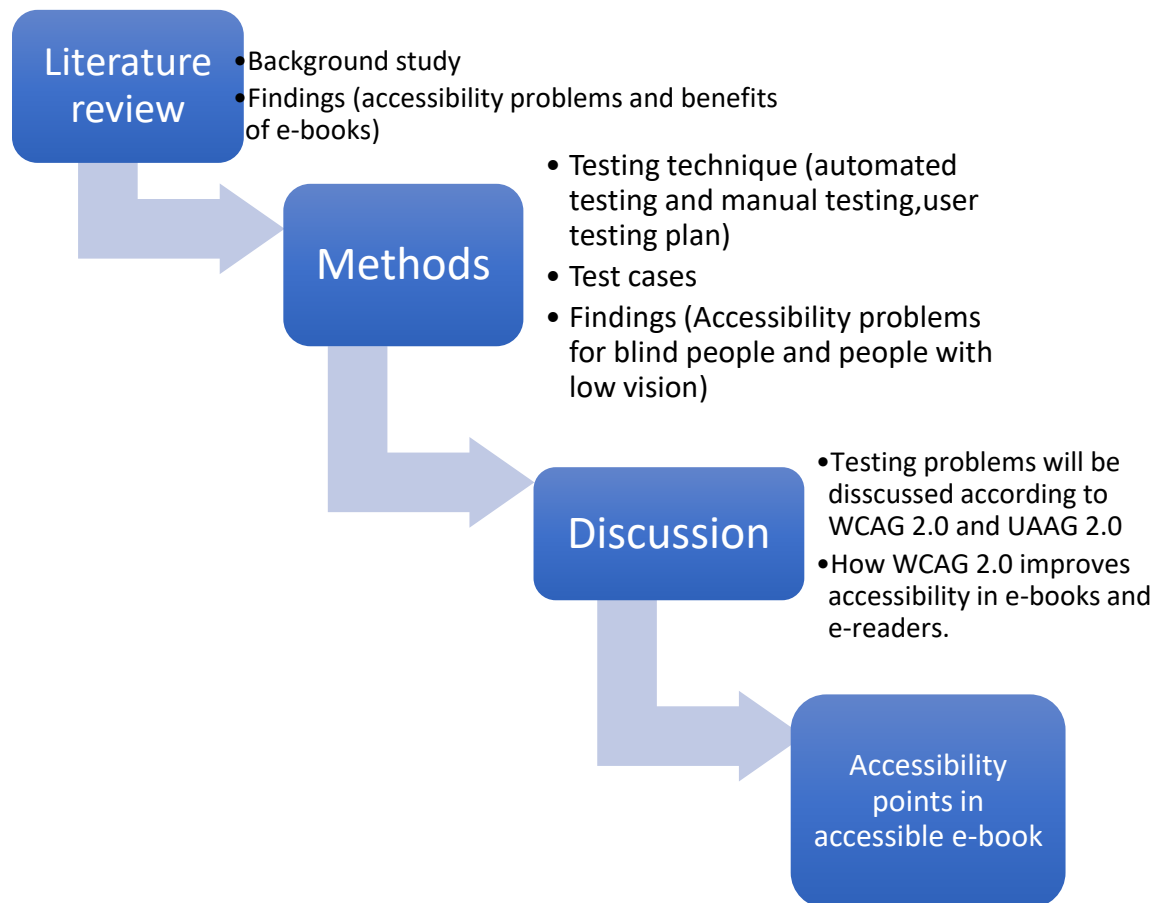


Figure 1.2 E-book accessibility Project phases

## 2. Literature review

Following are the background study of e-book accessibility. Background study shows the “e-book accessibility benefits” and “accessibility problems” for the people with some disability. People with disabilities including blind people, people with low vision, people with dyslexia, people with some physical disability, people with learning disabilities, but e-book accessibility research will follow the target group and that is blind people and people with low vision.

In the first part of the literature review possible benefits of e-book accessibility for the people with some disability will be discussed. How blind people and people with low vision is aided by the accessible feature in e-books. Accessibility features aided them and create good reading environment for the people with disability. Many accessibility features are used and people with disability used accessibility features and make the reading possible by using them. In the second part of literature review, accessibility problems will be discussed. Which type of accessibility problems people with disability are facing especially blind people and people with low vision.

### 2.1 Advantages of e-book

There are numerous benefits for e-book readers like mostly e-books are free, compact and have lots of storage capacity in it. In addition, we don't need to go to library or to any book shop to purchase it e-book are simply download and online access through internet. E-book content is very attractive. For instance, 3-D view of images, links, hyperlinks, reading order, video related data, audio data that make very interesting reading for the users. Moreover, there are many other accessibility options provided in an e-book that helped the people with disability. Printed books weight is very heavy and sometimes it is very difficult to carry them. On the other hand, e-books can be a form of software and it is kept in a very small storage devices (USB, external hard drive, CD etc.) E-book can be accessible everywhere in the car, park, shopping mall, kitchen through some portable devices (smart phone, laptop, tablets etc.) (Sasson, n.d.).

People have many advantages for reading e-book through some accessibility features. Sighted people have an issue with text size and difficult to read the text, e-book accessibility feature can increase the size of the text like in Amazon Kindle and other e-readers give the accessibility feature and people can change the font size, line spacing typeface and these are the better accessibility option for the people who have low vision. It is a very light weight device and the people who have some physical disabilities can easily carry the device (Orme, 2013).

Visually impaired users (blind people and people with low vision) use different screen readers to read the e-books on various devices like smart phones, tablets, laptop, desktop computers, iPad, android tablet and many other devices. iPad is considered very good device for accessibility point of view and it overcome many accessibility issues for the people with low vision and blind people and other people with disability as well like iBooks with VoiceOver screen reader. It has a very simple and user-friendly interface that is very helpful for those with cognitive disabilities. As the physical appearance of iPad that is helpful for people who have motor control problems because of its size. Due to assistive technology and accessibility tools, mostly problems are resolved, and e-book accessibility is achieved (Orme, 2013).

With the help of braille, blind people can do the book reading by themselves and no more dependencies exists between them and book reading. In early days, it was a great job to translate the text into the braille but nowadays, many computer software's and application has been introduced that easily translate the text into braille. National Library Service (NLS) for the blind users and other users provides the talking books so that they can enjoy the e-book reading. Moreover, braille books can be stored digitally (in the form of digital file) on the digital devices (flash, CD, USB, hard drive etc.). Visually impaired users (blind users and users with low vision) can easily download the braille books and braille devices and talking books for their reading (Danielsen, Taylor, & Majerus, 2011).

In addition, the Digital Accessible Information System (DAISY) provides different levels that make the e-book more accessible for the visually impaired users (blind and users with low vision). For

instance, heading mark-up, page-level navigation, predefined phrase movement and text and audio synchronization make the e-book more accessible. Different software's and hardware's are available in the market that allow the Digital Accessible Information System (DAISY) books to read in the full audio or braille devices. Moreover, Apple company introduces apple devices that is accessible for visually impaired user (blind and low vision users) e.g. iPhone OS, iPad, iPod and iBooks applications. Blind users can visit the iBook store application and purchase and review the e-books and free books are also available for the users. Visually impaired users (blind users and users with low vision) select the accessibility options from the Apple devices and choose the VoiceOver, Zoom, Invert Colors, Grayscale and Speech option according to their need. Reading books from iBook application user can browse the table of contents. Moreover, visually impaired users (blind and people with low vision) can select the topic from the table of content. In addition, user can read the book by character, word and line and user can flip the pages of the book and read the book aloud through VoiceOver option from the current page (Danielsen, Taylor, & Majerus, 2011).

Following (AbdelRazek & Modayan, 2012) there are lot of advantages of using e-books. For example, if we compared the electronic books and non-electronic books one major advantage is "*searching*". In e-books search the book contents, chapter title, any specific word and many other things is very easy. We can access another reference of related topic via hyperlink. On the other hand, it is very difficult in non-electronic books and sometime searching is impossible to some extent. E-book has no weight means e-readers are very light weight like smartphones, tablet etc. as compared to physical books. Physical books have much weight and sometimes it's very difficult to carry by the students, teachers and people with some physical disability as well. We can use external hard drive, flash drive and many other portable secondary storage devices to safe thousands and millions of electronic books. We can also save our books in out smart phones, iPad, android tablets and many other devices. Color contrast issues also handled and resolved for those people who have some color blindness.



Additionally, e-books are frequently used in educational purposes as well. TactoBook is assistive device that helps the blind people to read the electronic books and enhance the accessibility for people with disability. This device translates the content of the e-book in Braille (Velázquez & Pissaloux, 2007).

According to (Kanvinde, Rello, & Baeza-Yates, 2012) text books create millions of hurdles in reading and many people with dyslexia are unable to read the text books properly. Hence, they introduced the first e-reader application and people with dyslexia also take advantage of e-book reading through this application. E-book provides a better interface and layout according to the user demand and need. Provides an e-reader application in mobile devices for people with dyslexia for the first time, and there is no other application for the dyslexia people. The mobile application developed for the people with dyslexia and e-book reader contains spell checkers and phonetic dictionary that automatically converts wrong spellings to the proper spelling, speech recognition software, dragon dictate software and text to speech software. Most importantly, this application also provides the settings option for instance, people with dyslexia can apply the settings according to their need of reading and there is no such type of application that convert automatically the text into the people with dyslexia need.

(Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013) examined high school students with dyslexia and perceived their reading rapidity and conception on e-reader device and reading on paper and they found that high school students with dyslexia reading speed is better as compared to the paper reading. Due to the accessibility options and features provided by the developers and programmers to the impaired users and other people with disability and they can set the options according to their need and preferences. In the experiment dyslexia, high school student must perform the task: alterations in fonts, changes in page formatting and different approaches to rheostat reading dynamics.

(Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013) introduced the Span Limited Tactile Reinforcement (SLTR) method in the experiment that enable to display the large text in small

device. Gaze tracking technique introduced in another experiment were also improved the reading in Apple iPad with large font and determined that students with dyslexia reading was also improved through both experiments. Large text in small device is also help the people with low vision by doing the bigger vision of the text. These are the accessible methods that help the people with disability and make possible to do reading without any problem.

Moreover, format of e-books is depending on the technology of electronic devices and their display respectively. Most popular formats of e-books are Open e-books (OEB) and Portable Document Format (PDF). According to the Fischer and Lugg (2001) these two formats resolve many issues of accessibility in e-books to some extent, but some of the publishers feel hesitation while publishing the open formats, because open format doesn't have built-in-rights management control. On the other hand, PDF format contain management rights control, but difficult to fit in a small screen due to some poor resolution, no backlight and difficult to find the content.

According to Schneps, Thomson, Chen, Sonnert, & Pomplun (2013) there are numerous advantages of e-books that aid the people with print disability. The layout is very important in e-books and good layout helps to achieve the accessibility as well as to navigate the e-book content easily. Screen reader assistive technology translate the text in to audio and if e-book is designed in an accessible layout. For instance, table of content, headings, sub headings then the navigation through screen reader become easy.

According to AbdelRazek and Modayan (2012) navigation is very important and it based on good layout of electronic data. They also described many design features of e-book document for the people who have some sighted problem. Hence, certain advantages of e-book accessibility were discussed along their assistive technology. Moreover, how these people used the assistive technology and reading devices were discussed? Their experiences were also incorporated whether they were satisfied and happy with the existing reading devices was discussed.

Since, 1997 modifications to the Individuals with Disabilities Education Act, there has been a considerable demand for assistive technology to be included in the Individualized Education Programs (IEPs) of all students with disabilities (Osborne & Russo, 2007).

Riemer-Reiss and Wacker (2000) have stated that

*“Assistive technology devices enable individuals with disabilities to participate in society as contributing members”.*

Every human being is using technology to make their lives easy and comfortable. The people with print disability uses assistive technology to make their life comfortable and valuable.

According to the Hersh & Johnson (2008) the role of assistive technology leads a very high satisfaction for people with disability in their social life. Assistive technology overcome many problems and hindrances that stops visually impaired users and people with other disability and to participate in the society. By using the assistive technology people with some disability is using the e-document, e-book, web and other digital work independently.

Moreover, Carr, Gibson and Robinson (2001) describes many benefits of assistive technology as well as their usage. Assistive technology meets the user satisfaction level and make their normal routine work is as easy as their expectations. No more dependencies exist in the life of people with disability by using assistive technology.

E-books are now replacing school, college library's as well. Many schools have libraries that contain e-books rather printed books. These libraries also provide the assistive technology to those students with disability. To achieve the accessibility in electronic books it must be noticed that library must contain such materials that is accessible by everyone. For instance, for every type of person including those students who have disabilities.

According to GAREEMA and Shailendra (2014), library e-books must provide assistive technology for people with disability. Students with some disabilities take advantage from the e-book reading through some assistive technology. Assistive technology must be updated time to time because new advancement is coming day after day so updated assistive technology is highly recommended in the libraries. It is the duty of the librarians to update their library with new assistive technology. Moreover, they conducted a survey of fifteen different libraries in their article. Different accessibility features for blind users were used in the libraries. Blind people were using assistive technology in the library while reading e-books. Reading was possible through accessible tools and assistive technology. Moreover, they found that, there was no updated information about assistive technology in libraries, because new assistive technology was not updated. Different students with disability including visually impaired users were considered in the survey. Hence, library should be updated with new assistive technology as well as must contain all accessibility features in it (GAREEMA & Shailendra, 2014).

Osiceanu and Popa (2015) describe the importance of accessible technology. They conducted the research in which they introduced the advantages of Information Communication Technology (ICT) and in the end, they found that students showed great interest of ICT in educational field and access technology also aid them in using modern technology. This study will helpful for the visually impaired user for finding the job in the field of computer science.

Visually impaired users face many difficulties while reading printed books and most of them are unable to read printed books. Braille sometimes is used to read the printed books, but it is very expensive to produce. Further, visually impaired users (blind people and people with low vision) are dependent to someone else to read the content of the books, and sometimes it creates frustration among the persons due to long reading material. However, due to assistive technology and accessibility features, reading became easy and assistive technology help the blind users and users with low vision and people with some other disability to read the content of the e-books. DAISY (Digital Accessible Information System) provides an audio description for the printed books and it is very helpful for the blind and people with low vision users. DAISY is

basically the standard for those people who have some print disabilities. It provides great range of accessibility features like navigation and synchronization (Doush, Alkhateeb & Bsoul, 2014). Many software's are available in the market that convert physical books to some digital books for the blind people and screen reader users (Liesaputra & Witten, 2012).

To achieve the e-book accessibility two things are considered very important. One is an accessible document and the other is accessibility features (assistive technology and accessible tools) for electronic devices like smartphones, tablets, e-readers and personal computers. Document play a very important role in e-book accessibility. Arrangement of text in a document in terms of columns, headings and line spacing may affect the e-book readers and may also provide a good pleasure to the readers depend on the document structure. Moreover, columns and line spacing becomes very dangerous sometimes in e-books and reading through e-book devices become problematic due to style of text (font size, line spacing, heading style, number of columns etc.) Different formats of e-book, how these formats affect the reading? What type of issues and barriers occur must be considered? and user experience are also measured in this regard, while designing the e-book (Yi, Park, & Cho, 2011).

International publishers recommend Electronic publication (EPUB) standards and EPUB has the clear objective to achieve accessibility in e-book for the readers with some disabilities and no doubt, if all the e-book is published in this standard then accessibility can be achieved in e-book (Orme, 2013).

According to the Wilson, Landoni and Gibb (2002) user satisfaction plays very important role in e-books. Whether, the readers satisfied with reading through e-book same as paper book. Table of content is very important, because it helps the readers to navigate the contents of the books. Secondly, content and text in one page also very important for the readers while reading e-books. Shortcuts are also important like hyperlink, bookmarks and some other powerful tools that help the reader and they feel more comfortable in reading e-books.

Accessibility feature helps the people with disability to use the digital data (web, e-book etc.) without any problems. Accessibility guidelines make the accessibility possible in e-books. There are various accessibility features provided by the developers to increase the accessibility in e-books for the people who have some disability. These accessibility features will only work if e-book document is designed according to accessibility guidelines. Without accessible e-book document, there is no meaning of assistive technology. For example, text-to-speech is assistive technology in e-readers that help the people with disability to read the screen aloud. Navigation helps to navigate the e-book content and table of contents in e-book. Table of content is very important part in e-book and if it is properly designed according to accessibility guideline WCAG 2.0 and UAAG 2.0, then it became very easy to the blind people and people with low vision to navigate the e-book content through assistive technology (screen reader). Similarly, all the diagrammatical data, shapes, diagram, images, flow charts, video, animated data, tables, figures, audios will only be accessible through proper navigation in e-books and must be designed according to accessibility guidelines. Searching accessibility features helps the blind people and people with low vision to search the page, word, heading, paragraph and many other contents of e-book. Operational features along their audio feed back either the searching is successfully done or not and other feedback. Audio feedback of video related data. Font resizable, zoom in, zoom out and many other accessibility features helps the blind and people with low vision (Gunn, 2016).

Moreover, more accessibility features of e-readers and accessibility guidelines will be discussed in testing part. How assistive technology and accessibility guidelines help the blind people and people with low vision and without these technologies how many problems they faced while reading e-books.

According to (Holzinger & Miesenberger, 2009) the application is designed in such a way that it can be useful to everyone. There should be a framework and through this, an accessible application can be built. WCAG 2.0 web content accessibility guidelines and technique helps the developers to remove the accessibility problems in the future technology. WCAG 2.0 web content

accessibility guidelines provides different guidelines for different people with disability. They provide a better accessibility guideline for any people with disability. Like elderly people have many issues regarding searching. These guidelines provide a good opportunity for an accessible design. Moreover, in every development cycle, there should be some accessibility evaluation as well to conform that accessibility is under considered. A proper survey should be conduct on the users (who are going to use the software e.g. a user is going to read the e-book) by the responsible person who is responsible to manage the application. Survey should be on both usability and accessibility. What user wants to build the application according to their need and demand.

## 2.2 Problems of e-book accessibility

Beside of the advantages, there is also numerous inadequacy both in e-books and e-readers. People with some disability are still struggling in technology era with the deficiency of assistive technology and inappropriate e-book document format (document design is not according to accessibility guidelines). Due to the lack of assistive technology, they are unable to use the digital media (e-book, web, or other digital data).

Following (Crossland, S. Silva, & Macedo, 2014) electronic devices are rapidly growing in the era of advancement and everyone is experiencing from these devices. These devices create easiness in the human life especially the people with disabilities. Electronic devices play a very important role to achieve accessibility in electronic books because smartphones, tablets and computers provide some accessibility features that help the people with disability while reading the web content and electronic media.

(Crossland, S. Silva, & Macedo, 2014) created a survey that described how visually impaired users (blind people and people with low vision) were using these devices? (smartphones, tablets, computers etc.) Experience of visually impaired users (blind people and people with low vision) were recorded. During the survey, it was observed that the people with low vision used

accessibility options like zoom option to enlarge the images and text. The purpose to conduct the survey was to check whether visually impaired users (blind people and people with low vision) were satisfied with accessibility features (assistive technology and accessible tools) provided by developers in electronic devices. Online questionnaires were created only for blind people and people with low vision. People wearing glasses were excluded in this survey. There were two different formats of questionnaires one was in English language and other was in Portuguese language. Age of user group for English language was between 45 to 54 and between 24 to 34 for Portuguese language. Six candidates were below 18 years of age and only one candidate was above 85. The candidates could do calls, write text messages, internet surfing, use different applications, take pictures and videos from camera, read e-books and listen to audiobooks functions from the smartphones, tablets and computers.

After collecting the results, they analyzed that majority of candidate felt free while doing Internet surfing, making calls, writing text messages and use of different applications. They noticed that there were very few percentages of candidates who were reading e-books and listen to audiobooks and they found that these devices don't support enough accessibility features that satisfied the candidates. Results also showed that, mostly candidates were not interested to read e-books and listen to audiobooks because, it is too expensive, screen has no backlight and candidate were unaware of screen type. Accessibility options that were used by very few candidates with low vision was zoom option, speech and font selection (Crossland, S. Silva, & Macedo, 2014).

Hence, they conclude that there were very few people (no vision and low vision) that used e-books in smart phones and e-reader devices due to improper accessibility features and e-reader design (Crossland, S. Silva, & Macedo, 2014).

The major barriers were observed by (Crossland, S. Silva, & Macedo, 2014) in their survey was cost issue. Further, visually impaired candidates were unaware of how to use accessibility options



and features in these devices. In other words, they don't know how to operate accessibility feature in these devices may be these devices are not user friendly.

Lin, Chiou and Huang (2013) describes the barriers that creates problems in the success of Taiwan publishing industry. They found that e-books sales are very few although, different Taiwan publishers are involved in this activity. Two major problems they found in the article, one lacked e-book title and other was issues with the in e-readers. According to the Lin, Chiou and Huang (2013) Taiwan readers faces many problems due to the cost of these electronic devices. Moreover, it was observed that personal computers are becoming more popular to read electronic books, but personal computers are not portable and the people some print disability are bound to read the e-books at home or offices. On the other hand, smartphones resolve the issue of portability, but the main problem discovered in smartphones was small size, backlight and short battery lives. According to the Lin, Chiou and Huang, (2013) developers should focus on more digital devices that must follow accessibility guidelines and devices should be user friendly so that e-book reading will become more popular and people with disabilities can easily read and enjoy through these devices.

Despite of all, Fischer and Lugg (2001) states that:

*“So far, the e-book industry has been difficult to track, at least in part because of its broad base and its consequently vast variety of new formats, devices, platforms, distribution models, and rights management strategies.”* (“For better or worse”, para.2)

The design of reading devices should be user friendly so that they can easily grasp the new technology and easily operate the accessibility features in these devices. Electronic book reading devices is becoming very popular and lot of people experiencing good, while reading e-books especially students, researchers and libraries but due to electronic devices cost and e-book format it creates financial problem for the e-readers (Fischer and Lugg, 2001).

According to (Holzinger & Miesenberger, 2009) inaccessibility also creates problems in information technology for the student life. A student who have some disability are unable to read the learning material in the class room and in home as well due to inaccessibility in reading devices. A teacher responsibility whether the learning material that are using in the class room are accessible for everyone including a student with some disability. Accessibility guidelines provide the fundamental rules of accessibility and by using WCAG 2.0 web content accessibility guidelines accessibility can be achieved.

E-books are also readable the students and there are many e-books are available for the students and they are using them. But unfortunately, an accessible e-book is unavailable for the blind student and student with some disability. Technology is getting advanced day by day and this is the era of technology. Everything is accessible through digital media. Almost in every education field e-learning becoming more popular. Unfortunately, still some issues are facing regarding inaccessibility for the student with disability in this technology era. Blind student is facing problem in learning with visual tool. They are highly inaccessible for them. The result is that blind students can do nothing and helped many times for the teacher and other students. The next thing is that, these e-books should be accessible for the student with some disability. E-book should be designed according to their WCAG 2.0 accessibility guidelines and techniques. For instance, a mathematic book contains many diagrams, formulas, shapes etc. so theses mathematical e-book content should be accessible for the blind student. All the images should be accessible for the students who have vision problems. Easily readable by screen reader and other accessible tools (zoom in, zoom out, color change option, font size, font style etc.) for the low vision people. A teacher should confirm that learning material (e-books and other learning material) is accessible before introducing it in front of students (Holzinger & Miesenberger, 2009).

Many school's books are provided in digital form, but these are highly inaccessible for the blind students. Mostly books are without alternative image description, table are not accessible. Moreover, mostly e-books are designed in a sequential structure and it seems very difficult to

blind student to go back and forward because students are using the book so many times to read rather than a story book that are read by only once time (Holzinger & Miesenberger, 2009).

Many e-books are inaccessible because author is unaware about the accessibility guidelines. They are not properly following the WCAG 2.0 accessibility guidelines to make the e-book accessible before publishing it into the market. There are very less accessible tools or assistive technology don not fully supported the e-book content. For instance, mathematical formulas are unable to read by the screen reader and formula's description are not fully provided to make e-book content accessible (Holzinger & Miesenberger, 2009).

Internet and world wide web are a powerful way for the students and provide better learning environment. Many students get information through the web and internet. E-learning is very important in this era of advancement, but due to the web inaccessibility sometimes e-learning becomes impossible, especially the people with print disabilities. However, many developers, e-book retailer are doing tremendous work to overcome the e-learning inaccessibility by developing the new assistive technology and reading systems for the reading devices, but still more advancement is needed in this era (Armstrong & Murray, 2007).

According to Mothiravally, Ang, Baloch, Kulampallil & Geetha (2014) in developing countries visually impaired users got equal opportunity to some extent and they are simply ignored in non-developing countries. For instance, by using the accessibility features visually impaired users can use the digital media and assistive technology and accessible tools helps them to use the digital media easily. But still advancement is needed in term of accessibility for the visual impaired users. (blind people and low vision people).

A survey conducted by Mothiravally, Ang, Baloch, Kulampallil & Geetha (2014) in which many visually impaired travelers are participated. In survey, different activities conducted to find out the dependencies in visually impaired travelers. For instance, they want to know that how much accessibility helps the visually impaired users, and they can use to do the things independently

or by themselves without the interference of third party. In the survey, visually impaired users did the online booking of tickets and they found highly inaccessible website and unable to book a ticket online due to inaccessibility. A lot of dependencies exist, and they helped by the third person to book the tickets.

Some problems and barriers described by Armstrong and Murray (2007) that faced by the visual impaired student (blind people and people with low vision) in their article. Some e-learning material containing graphical data and visual data and are unable to access for the blind people. However, zoom option can only have helped for people with low vision, but it is totally inaccessible for the blind people. Armstrong and Murray (2007) writes about computing education in their article and describe how computing theory effect the visual impaired students? For instance, Computing theory contains lot of shaded diagram along their different sizes, textures, visual effects and with proper sequence. Hence, it creates problem for the visually impaired students. Some assistive technology is also discussed by Armstrong and Murray (2007) that helps the visually impaired users to achieve the Internet accessibility to some extent, but assistive technology had some limitations with the computing students and these are: a very limited assistive technology and accessible tools is provided by the developers like screen reader, text magnification applications and braille display units, but these assistive technologies sometimes doesn't work with graphical data. Screen Reader are unable to access the nontextual data like visual data, diagram and pictures etc. Moreover, Braille display unit is very costly and only operated by those visually impaired users who better know how to use this device.

In addition, Armstrong and Murray (2007) states that:

*“One of the core applications used in the CCNA courses is Packet Tracer ([www.cisco.netacad.net](http://www.cisco.netacad.net)). Packet Tracer is a Macromedia Flash application which uses images, not text, to display information. As screen readers do not work with Packet Tracer, only sighted students are able to use it. This was a major problem needing to be solved in order to give vision-impaired students access to this material.”* (“E-LEARNING MATERIALS”, para. 4)

Hence, due to limited availability of accessibility features visually impaired students (blind people and people with low vision) skip the learning contents.

Lane (2006) evaluate the e-textbooks in his research and determined that whether the students were feeling comfortable with the e-book interface design. He created a web-based survey, in which his findings demonstrated that mostly users showed disappointment, because they were unable to edit, mark and interrupt with the e-textbooks. Hence, these features played important role while promoting e-book reading and sometimes people with disability don't know how to operate accessible tools and assistive technology.

Typical issue that provoked inaccessibility in e-books reading are improper file format. Production team sometimes ignore some accessibility features that creates problem for people with print disability. For instance, e-book document layout is not according to accessibility guidelines and technique and screen reader could not properly read the table of content due to inaccessibility in e-book document. Moreover, there is no proper interface. For instance, no accessibility options are provided that change the foreground and background color. People are unaware the use of accessibility features sometimes and there are very few percentages of people with print disability that know accessibility features and their use. Most importantly, many e-reader devices don't support accessibility features (accessible tools and assistive technology) like color contrast, enlargement of font, and many other features and create hindrance to achieve the accessibility (McNaught & Alexander, 2014).

### 2.2.1 E-book formats

Every electronic device has its own e-book format. For instance, e-book formats are Amazon Kindle e-book file (AZW) from Amazon, Mobile (MOBI) from MobiPocket (now Amazon), Electronic Publication (EPUB) and Portable Document Format (PDF) from Adobe. The best e-book

format is very necessary, because if the e-book format is good then people can use it easily, can search anything from the book without any problem, format further can be used to any screen size. Moreover, all the content of e-book is easily accessible through good e-book format for all the people with some disability. Good format is helpful for designing the good accessible e-book content especially, for the blind and people with low vision, because mostly problem came in blind people and people with low vision in term of accessibility. In Mobipocket format, there is a good presentation of images as well as text. In other word, it supports image and text accessibility in e-book, but it doesn't support the audio, video and animated data. Amazon kindle is the e-reader and it support Mobipocket format. Diagrams related data and mathematical formulas are not readable by this format. KF8 format is also work on Amazon kindle, but this format has no text-to-speech option, and without the text-to-speech option it will be impossible to read the e-book content for the blind people and people with low vision. Another format of e-book is iBook and it run on only in apple devices. iBook have issues regarding layout, but it is a good regarding accessibility (Turčić, 2018).

## 2.2.2 Standard of electronic publication

According to Kataoka, Amagasa, and Kitagawa (2013)

*“EPUB is a standard for electronic publications created and maintained by IDPF (International Digital Publishing Forum). The current version of EPUB is EPUB3.0. An EPUB publication is comprised of a number of files; the content is represented as XHTML or HTML5, while the layout of contents is described using CSS. The metadata, such as bibliographic information, table of contents, etc., are represented as XML files. Moreover, it supports various media types, such as vector graphics (SVG) audio, and videos (e.g., SMIL) As can easily be seen, EPUB depends only on open standards, and does not rely on proprietary technologies.”* (“EPUB”, para.1 & para. 2)

Application must be user-friendly so that it can be useful easily and understandable as well. The application can be any application for any product. For instance, in e-book e-reader's applications are available in which different e-books can be read and people with disability uses application assistive technology or accessible tools to make reading possible. Hence, a proper interface must be user friendly and easily understand by the visually impaired users (blind people and low vision people). Interface also be easily readable by the screen reader. They can access the information through the assistive technology in the reading applications (e-reader's apps). So, application interface should be user friendly and accessible to them (Burger, 1994).

Assistive technology plays a vital role to access the digital content and is very helpful for blind users and low vision users. On the contrary, more advancement in assistive technology is needed so that they can use the digital media more comfortably. Barriers that describes by (Suomi & Sachdeva, n.d.) in their article and according to their point of view, these barriers were a great hinder to achieve the accessibility level in e-book. Firstly, social conditions effects badly on blind people. For instance, in our society mostly people took pity and sympathy on them and it make blind users uncomfortable and most of them didn't adopt the assistive technology. Secondly, every person has a right to spend his or her life according to their wishes and demands. Similarly, blind users also wish to control over their surroundings and their expectation towards assistive technology is very high. On the other hand, assistive technology leads their expectations down sometimes loss of trust towards technology is happened. Thirdly, sometimes, assistive technology is very advance and difficult to understand (devices are not user friendly). How to operate the technology over devices? This is the major problem in visually impaired users that how to use this technology? Fourthly, social embarrassment also leads them down and create problems to assistive technology acceptations. A proper survey is conducted by Neeraj Sachdeva and Reima Suomi to check whether the above socio-psychological attributes effect the visually impaired users to achieve the accessibility? They conducted the interviews and found both positive and negative expectations towards assistive technology in terms of above socio-psychological attributes. They found that, these attributes were very important, and developers

and programmers must have noticed these socio-psychological attributes and developed assistive technology for everyone (Suomi & Sachdeva, n.d.).

Accessibility is a very important for everyone and for the people with disability sometimes missed the information due to inaccessibility. Accessibility laws should have applied in everywhere so that every person use the digital world without any barrier.

Accessibility laws has been approved in many countries and according to the law it is the responsibility of the publisher to provide accessible version of printed books to the visually impaired students and blind students (Contini, Leporini, & Paternò, 2008).

According to the (*"Association of Tech Act Projects", n.d.*)

*"in order to bring accessibility considerations into the technology development of the [W3C] Web Consortium and to determine guidelines for accessible technology including web authoring and user agents (browsers). As Tim Berners-Lee, the inventor of the Web, and the Director of the W3C put it, 'The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect' ("The web Accessibility Initiative guidelines (WCAG)", para 1)*

The people reading e-books are satisfied due to its accessibility options and these options create easiness in reading especially for visually impaired users (blind people and people with low vision). Printing books doesn't provide accessibility options and creating difficulties in reading for visually impaired users (blind people and people with low vision).

People with low vision uses magnifier option while reading the content of the book. Some users use screen reader to read the book. Further, e-books content contains some graphical e.g. charts, tables, images and diagrams that sometimes are unable to read by screen readers and creates problems. Screen Reader should read each content of the book whether it is in any format (HTML, PDF, TXT etc.) to remove this barrier navigation feature and alternative text options are introduced that read tables, images, graphs and diagrams. All screen reader should be accessible



by assistive technology and able to identify all content of e-book same as physical book (Contini, Leporini, & Paternò, 2008).

(Maatta & Bonnici, 2014) describes the accessibility types for blind people, low vision and people with dyslexia in e-readers over print disabilities. They also describe how three computer devices accessibility affect these people with impairment in e-book reading. They evaluate three main categories in their research and these were product comparison, assessment and design of e-readers and e-books. Most importantly, the main thing was to examined is that no vision, low vision and users with dyslexia can use and read the e-books in the same way as sighted users. Moreover, which electronic device is better in terms of reading accessibility.

The office of civil rights of the united states department of education (2010) describe the accessibility statement

*“Students [who are blind or have low vision] must be afforded the same opportunity to acquire the same information, engage in the same interactions, and enjoy the same services as sighted students.”* (Maatta & Bonnici, 2014, p.497)

### 2.3 WCAG 2.0 and UAAG 2.0

WCAG 2.0 Web Content Accessibility guidelines provide a standard guideline in all over the world. These guidelines were established by the W3C World Wide Web Consortium process with the collaboration of many people and organizations. WCAG 2.0 published in December 2008 and now WCAG 2.1 was published in June 2018. WCAG 2.1 covers all the accessibility guideline of WCAG 2.0. WCAG 2.0 provide an accessible guideline to web content (Caldwell, Cooper, Reid, & Vanderheiden, 2008).

UAAG 2.0 User Agent Accessibility guidelines gives us a better accessibility feature. In other words, user agent accessibility guidelines provide us assistive technology in digital devices for the

people with disability. For instance, user agent is a reader and assistive technology help the people with disability in e-book reading and make it accessible for them. Assistive technology for blind people is screen reader who read the screen for them (Allan, Lowney, Patch, & Spellman, 2015).

## 2.4 Web content and web accessibility

Web content are document language, tables, headings, labels, links, hyperlink, images, diagrams and many other contents. Hence, e-book content is somehow the subset of web content. From now, there are no proper accessibility guidelines are introduced for e-book that's why, web content accessibility guidelines are used in the research to find out the accessibility problems in e-books.

The web is a great source to access information, to interact with people and to participate in the society in many ways. An accessible website can help the people with some disabilities to do lot of normal things. For instance, visually impaired users can read the books and newspaper online and do many other online tasks according to their needs and wishes. Hence, reading through accessible website help the users with disability to access the web content online.

According to Petrie, Savva and Power (2015)

*“Web accessibility means that people with disabilities can use the Web. More specifically, Web accessibility means that people with disabilities can perceive, understand, navigate and interact with the Web, and that they can contribute to the Web”* ( “Introduction “, para 3).

Petrie, Savva and Power (2015) propose different definitions of web accessibility drawn from the different books, papers, standards, guidelines and online sources. They introduced onion diagram that defines the web accessibility definition as follows:

*“all people, particularly disabled and older people, can use websites in a range of contexts of use, including mainstream and assistive technologies; to achieve this, websites need to be designed and developed to support usability across these contexts” (“Results”, para 5).*

## 2.5 Why WCAG 2.0 for e-book document

Web accessibility is for website, but web content accessibility guidelines provide the accessibility guidelines to the web content. In e-book accessibility, all the e-book content must be accessible and web content and e-book content is somehow very similar. It can be said that e-book content is the subset of web content. The content that are in website also in e-book. Moreover, there are no specific accessibility guidelines are designed till yet for the e-books that’s why web content accessibility guidelines will be used in this research. Research follow the WCAG 2.0 accessibility guidelines because WCAG 2.1 is introduced in the June 2018 and research work has been started before the WCAG 2.1 accessibility guidelines.

Hence, from the above background study it seems that e-book accessibility is something depend on both assistive technology, accessible tools and e-book document. Assistive technology helps the people with disability while reading the e-book through some accessibility features assistive technology and an accessible tool like zoom in, zoom out, font resizable, screen readers and many others accessibility features. If e-reader contain all required assistive technology and accessible tools for the people with disability and e-book document is designed according to accessibility guidelines, then e-book is accessible otherwise e-book is inaccessible.

In addition, e-book document should be format according to Web Content Accessibility Guidelines (WCAG 2.0) and assistive technology and accessible tools should be according to User Agent Accessibility Guideline (UAAG) to achieve the accessibility. In short, both e-reader and e-book document must be compatible with each other for accessibility. In addition, compatibility means e-book content is accessible through some assistive technology and accessible tools in e-

readers for blind people and people with low vision and other people with disability. Moreover, all the e-book content (table of content, heading, title, images, label, text, paragraph etc.) is accessible or compatible according to their assistive technology that are designed for the people with disability. In other words, all the e-book content should be readable with respect to their assistive technology (screen reader) and accessible tools (font resize, change font style, font color, background color etc.) for the people with some disability.

### 3. Methods

In the methods chapter, different testing techniques will be discussed and applied in e-book accessibility research to accomplish the research goals. Testing techniques helps to find the accessibility problems in e-books to answer the research question one. Three testing techniques automated testing, manual testing and user testing will be used in e-book accessibility research. User testing plan will be discussed in this research but testing with the real users will not be done in this research.

#### 3.1 Choice of methods

The testing technique is chosen in this research is, because e-book accessibility research is basically to find the accessibility problems in e-books and accessibility problems will only be identified after test the e-books. That is the reason, different testing technique is used in this research to find the e-book accessibility problems for the blind people and people with low vision. The research question one is as follows:

What are the specific problems and characteristics of e-book document and e-reader in term of accessibility for blind and people with low vision?

So, aim of the testing technique is to answer the research question one after testing the e-books for the blind people and people with low vision. Testing techniques provide a better platform to achieve the research goal. Testing techniques uses different testing plans, but the outcome of test plan is one and that is accessibility problems in e-books and e-readers (assistive technology and accessible tools).

The aim of testing the e-reader assistive technology and accessible tools is because e-book contents are readable with the help of some assistive technology and accessible tools for the blind people and people with low vision as well as other people with disability. For instance, using the text-to-speech assistive technology blind people and other screen reader users listen the

words of e-book document. If e-readers doesn't provide a sufficient assistive technology to the blind people and people with low vision, so they cannot read or access the e-book content and then it also causes the e-book inaccessibility. Due to the lack of assistive technology, blind people and people with low vision are unable to read the e-book content properly that's why, e-reader assistive technology and accessible tools are also be the part of the research to find out the accessibility problems in e-books. Why the e-books are inaccessible? What are the accessibility features (assistive technology and accessible tools) that are missing in e-readers? Accessibility features are assistive technology (screen reader) and accessible tools (people with disability can adjust accessibility features according to their need, change font style, font size etc.) that help the people with disability.

### 3.2 Testing techniques

Research will be followed three testing techniques automated testing, manual testing and user testing. Due to the time constraints and unable to find the real users (blind people and people with low vision) in a short period of time, it couldn't possible to me to conduct a user testing, but how the user testing will be conduct and what attributes will be involved in user testing will be discussed in this "e-book accessibility" research.

Interviews are in the form of questions that will be asked to the real users (blind people) about the e-book accessibility. Questionnaire related to e-book accessibility will designed for the people with low vision. People with low vision will fill the questionnaires and share their experience on e-book accessibility. For instance, what type of e-books accessibility problems they faced during the e-book reading. User testing give the more ideas to the developer and to the publisher to provide more accessibility features in e-books and in e-readers and overcome the inaccessibility in e-books.

### 3.3 Why automated testing is conducted

Automated testing technique has been chosen in the research, because it is very easy to identify the e-book accessibility problems with the large e-book (e-book that contain lot of pages, images, links etc.) through automated tools. It will be very difficult to conduct a manual testing for large e-book and to check all the accessibility problems in it. That is the reason, automated testing technique is used in the research to find the possible accessibility problems in e-books.

Automated testing will be conducted through some online tools. Bluemix Digital Content Checker by IBM and EPub Validator is used to identify the possible accessibility problems (errors) in e-book. Further, these errors will be compared according to WCAG 2.0 accessibility guidelines and techniques. It is noted that in automated testing only the e-books document accessibility will be test, because automated testing tool takes the e-book as input and generates the accessibility problems for the e-books. Assistive technology and accessible tools of e-readers will not be the part of automated testing.

### 3.4 Why manual testing is conducted

Manual testing technique has been chosen in the research, because to find more accessibility problems or the problems that are skipped in automated testing will be identified in manual testing. It is noted that all the accessibility problems are impossible to test but possible accessibility problems will be tested in manual testing.

In manual testing, possible accessibility problems faced by blind people and people with low vision will be tested. Through testing, compatibility of e-books with e-reader will also be tested. For instance, whether the e-book content properly readable through assistive technology in e-readers. Where the inaccessibility exists in e-book document, in assistive technology in e-readers or in both (e-book and e-reader) will be tested. For instance, if there is video data in an e-book, then blind people and people with low vision understand the exact video in the e-book with the

help of assistive technology will be checked in manual testing. On the other hand, whether e-book content is according to accessibility guidelines will also be checked in manual testing.

Hence, all the testing techniques have their own importance and advantages. The purpose of testing techniques will be the same and that is to identify the accessibility barriers in e-books. In addition, identified problems will be discussed with accessibility guidelines in the discussion chapter.

### 3.5 Automated testing

Automated testing automatically generates the results of testing after entering the testing file. It is a very quick process to identify an error in any type of file. There is no need to write any special test cases in automated testing. Just insert the file and it will produce a testing result. This process saves time as well as is done in low cost (Polo, Reales, Piattini, & Ebert, 2013).

#### 3.5.1 Automated testing tools

There are two automated testing tools that will be used in this research to identify the possible accessibility errors in e-book documents. Automated testing just takes the e-book as an input and generates the possible e-book accessibility problems. Following tools are used in automated testing

1. Bluemix (Digital Content Checker).
2. EPUB validator.

##### *3.5.1.1 Bluemix (Digital Content Checker)*

Bluemix is basically the completion of IBM. In the Bluemix platform, many services are provided by the (International Business Machine) IBM to the developers. IBM provides many facilities to its developers to manage different types of applications. Developers can create, develop, deploy and manage their application through different services provided by IBM in Bluemix. Digital



Content Checker is a service provided by IBM in Bluemix that automatically test the EPUB and html files according to Web Content Accessibility Guideline (WCAG 2.0). After scanning the EPUB file it provides the report that contain Potential violation and violation according to WCAG 2.0 accessibility guideline and accessibility guidelines provided by IBM. IBM Digital Content Checker has its own accessibility points including WCAG 2.0. Digital Content Checker also helps the users to overcome these violations by providing the report before publishing the e-books so that maximum accessibility could be achieved ("IBM Cloud - Next-Generation Cloud App Development Platform", 2016) ("Getting started with Digital Content Checker (Experimental)", n.d.).

### *3.5.1.2 EPUB validator*

Through automated testing, automated tools are used that checks the accessibility in e-book. For instance, International Digital Publishing Forum (IDPF) automated tool is used to check the accessibility in e-books, but automated tools don't detect or check all the accessibility problems in e-book. Through some automated tools only 30 % accessibility problems can be test. To find out more accessibility issues in e-books manual testing is conducted in which human being are involved to conduct the testing more deeply ("Introducing ACE: Accessibility Checker for EPUB ", 2017). EPUB validator (automated tool) will be used to detect the accessibility problems in the tested e-book. ("EPUB Validator (beta)", n.d.).

## **3.6 Manual testing**

Manual testing is a testing strategy to test software or any product to determine its error. The product can be a website, e-book, or a piece of code anything. This is the responsibility of the developers, software engineers, testers to test the software before deployment. They check the efficiency of the software whether the software meet the client requirement and according to customer need. They create different test cases to find out the bugs in the software while conducting manual testing. All the work in manual testing is done by the tester. Tester, developer

test the software modules by themselves and by writing the test cases without using online automated tools. Their aim is to find more errors that are not identified by online tools to achieve the customer satisfaction level. Test plan are created to test different functionality of the software. After the testing, results will be compared with the actual output or desired output. Through test plan manual testing is easily done. If the result is not according to desired output, then the result is basically being considered errors (Sharma, 2016).

If I discussed the above discussion of manual testing in e-book accessibility research, then bugs are basically the accessibility problems found after testing the e-book. In other words, bugs are the results of the testing techniques in e-book accessibility research. Software is the e-book and customers are the blind people and low vision people. Hence, the manual testing is to check the e-book to find out more accessibility errors for the blind people and people with low vision.

According to Sharma (2016) defines the cycle of conducting manual testing. So, the manual testing of e-book accessibility research contain proper cycle as follows:

- Write Test case
- Test the e-book against every test case
- Error Report
- Link the error according to WCAG 2.0 accessibility guideline and UAAG 2.0 guideline

### 3.6.1 Manual testing cycle

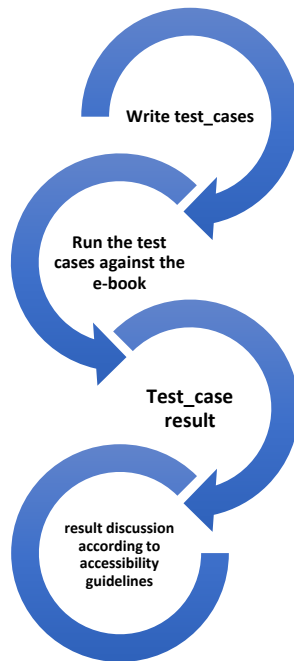


Figure 3.1 Manual testing cycle by Sharma (2016)

First, possible test cases will be written according to the target group defined in research introduction part. Target group is blind people and people with low vision. Second, each test case will be executed in e-reader app with e-book. In other words, e-book accessibility will be checked in two different e-readers app and e-book. Is e-book document accessible or not and e-reader app (iBook, Kindle) provide accessibility features to the blind and people with low vision. E-book will be tested manually to answer the research question one. (What are the specific problems and characteristics of e-book document and e-reader in term of accessibility for blind and people with low vision?).

### 3.6.1.1 Test cases

Following are the possible test cases designed to conduct the manual testing in e-book accessibility research. Test cases are written to check the accessibility problems in e-books. Accessibility problems of e-books identified by the background study and some accessibility features are base of writing test cases for the manual testing. These accessibility features are

visual elements (images, diagram, shapes, pictures and other non-text data), punctuation marks, abbreviation, navigation, hyperlink, label heading, line spacing, font size, font style, and many other possible features. Whether, these features were designed according to WCAG 2.0 accessibility guidelines. For example, visual elements had alternative text or not. Punctuation marks were readable by blind and people with low vision or not with some assistive technology. Abbreviation contained extra information and explanations or not. E-book was accessible to navigation perspective like table of contents, headings, sub headings, list, paragraph, line spacing etc. If e-book had a hyperlink, then it was accessible or not.

In addition, iBook e-reader app assistive technology (screen reader, zoom, color contrast and many other) is tested and checked whether the e-books are compatible with e-reader assistive technology. What accessibility problems came when e-reader's assistive technology is insufficient with e-books?

#### 3.6.1.1.1 Test case 1

Test case no one is to check the e-book document formatting e.g. proper style for table of content, e-book title, heading, sub heading and section heading, formatting (line spacing, paragraph spacing, font size, font style (same font and font size is applied through all book)), page numbering, header and footer, will be tested. If book contain images, then proper image color must be defined to avoid color contrast issue for the people with low vision. One style is used throughout the whole book document will be test.

#### 3.6.1.1.2 Test case 2

In this test case, abbreviation full form will be tested. If the e-book contains some abbreviations, then it will be check either the full form of abbreviation is in the book content or not? Moreover, whether the e-reader has assistive technology that provide the full form of abbreviation whenever abbreviation came in the e-book document will be test in this test case.

#### 3.6.1.1.3 Test case 3

Checking the pronunciation of the words or check the screen reader words pronunciation in e-books document. By checking the screen reader pronunciation, e-reader assistive technology is tested. Screen reader pronunciation will check, pronounce word as it can be easily understandable by the screen reader users. Some English words are very similar in terms of pronunciation like homophone words and the words whose pronunciation is same. Homophones words examples are (axis, axes) and (bail, bale). For blind people, it may be difficult to understand the meaning of homophones. If e-book contains homophones words, then extra explanations must be there to describe the homophone words in the e-book document. Hence, in this test case pronunciation of the screen reader, text-to-speech software will be tested as well as homophones description is present in the e-book document and e-reader assistive technology provide an extra information of homophones in e-readers will be tested in this test case.

#### 3.6.1.1.4 Test case 4

Check the punctuation mark whether punctuation marks (exclamation mark, question mark, direct speech, quotation marks) is readable by assistive technology according to their sentence expression or not. For instance, if there are some surprise full effects in the book or some sentence are enclosed in the quotation marks then either the screen reader reads the punctuation marks and create a scene according to specified expressions (direct notation, question marks, exclamation mark and other punctuation marks) to the blind people or not will be test in the test case.

#### 3.6.1.1.5 Test case 5

In this test case, the navigation is tested. Screen reader can navigate the e-book content only when the e-book is fully formatted according to the WCAG 2.0 accessibility guidelines and technique. Moreover, the document must be formatted all the tables, paragraph, headings, sub

headings, section headings, page title, lists, number list, bullet lists, links, hyperlinks, references, table of content, header and footer, page number must be according to the accessibility guidelines and techniques. If e-book is formatted according to accessibility guidelines, then it will be easily navigable by screen reader. Hence, in this test case, navigation will be tested.

#### 3.6.1.1.6 Test case 6

In this test case, the magnification option is tested excluding of assistive technology of e-reader. Excluding of assistive technology means in this test case font resize (people with low vision can change the font size according to their need) able option will be test inside the e-book document. E-reader accessible tool in which font resize able option is provided to the people with disability including people with low vision, but in this test case font resize able option is checked inside the e-book document. In addition, it will be tested whether the e-book content has font resize able option. Font resize able test is for the people with low vision. There should be some inline option in the e-book content to change the font size so that the people with low vision change the font size setting according to their need.

#### 3.6.1.1.7 Test case 7

In this test case, the font style option is tested excluding of assistive technology. Excluding of assistive technology means in this test case font style option is test in the e-book. E-reader provide the font style accessible tool to the people with low vision, but in this test case font style option is checked inside the e-book document. In addition, it will be tested either the e-book content has font style option or not. Font style options helps people with low vision while reading the e-book content so that font style option should be embedded in e-books excluding of assistive technology.

#### 3.6.1.1.8 Test case 8

In this test case, alternative text is tested on all images, diagram, shapes, table, abbreviations, homophones words (words with same pronunciation). Moreover, alternative text should be a meaningful text so that blind people easily understand the purpose of all pictorial representation stuff as well as abbreviation and homophones words.

#### 3.6.1.1.9 Test case 9

In this test case, graphs are tested. For instance, if the e-book contains some graphical information or some statistical data then there should be some alternative description of text should be there for the blind people and people with low vision.

#### 3.6.1.1.10 Test case 10

In this test case, reading order is tested in e-books. A good layout and reading order help to navigate the e-book content easily. So, proper reading system means book contents e.g. book chapters, index, book description, reference and other information should be in proper order and this order make the navigation easily will be tested in this test case.

#### 3.6.1.1.11 Test case 11

In this test case, tables (data in the tables) are tested. For instance, if the e-book contains some tabular data then a proper description of tabular data should be provided through some alternative text description and alternative text should be meaningful and easily understandable. Moreover, whether table is designed according to accessible guidelines or not. For instance, if table row, column and header row is accessible by the screen reader. Header row must be repeated in every page of the document.

#### 3.6.1.1.12 Test case 12

In this test case, it will check whether there is any image containing text. If image containing text is found, then it is accessible or not. For instance, the meaning of text in the image are understand by the blind people.

### 3.7 Testing techniques expected result

Testing techniques results will be the possible accessibility problems in e-books and lack of assistive technology and accessible tools in e-readers. Finding of testing technique will be the e-books accessibility problems and this is the answer of research question one. Further, e-book accessibility problems will be compared according to the accessibility guidelines and techniques. Testing result will be compared according to WCAG 2.0 and UAAG 2.0 accessibility guidelines and technique, and how can accessibility guidelines will improve the e-book accessibility for the e-book document and e-reader will be discussed in the discussion chapter to answer the research question two. After the answer of both research questions, an accessibility point for an e-book document will be recommended and suggested to the publisher from the researcher of this research with the help of WCAG 2.0 accessibility guidelines. Recommendation of accessibility points are only for the blind people and people with low vision.

### 3.8 How WCAG 2.0 and UAAG 2.0 improves accessibility?

Four principles of WCAG 2.0 accessibility guidelines and techniques provide the guidance to create an accessible document and an accessible website. UAAG 2.0 User Agent Accessibility guidelines provide five principles of accessibility and guidelines. Hence, 1, 2, 3 principles are almost same to WCAG 2.0 accessibility guidelines and technique. Fourth and fifth principle deal with the assistive technology and user agent in UAAG 2.0 user agent accessibility guidelines and techniques. E-book should be presentable and everyone (all the people including people with disability) can use the e-book easily. E-book is easily navigable through screen reader, the e-book content and interaction with e-book content is understandable. Further, the assistive technology and e-book content is compatible with each other. Moreover, user agent provides some features



in e-reader to make the reading easy through assistive technology and accessible tools. User agent accessibility guidelines help the author to implement these accessible guidelines. Author should be sure before make e-book available to e-shop and confirms that e-book is designed according to WCAG 2.0 and e-reader has UAAG 2.0 assistive technology and accessible tools to the people with disabilities (Caldwell, Cooper, Reid, & Vanderheiden, 2008) (Allan, Lowney, Patch, & Spellman, 2015).

After conduct testing, results will be compared and discussed according to the WCAG 2.0 accessibility guidelines and techniques. Accessibility guidelines help to make the e-book accessible. The guidelines help the blind people and people with low vision and people with other disability as well in reading e-books. Problems associated with e-book document are discussed according to WCAG 2.0 accessibility guidelines and technique. Lack of assistive technology associated with e-readers are discussed according to UAAG 2.0 accessibility guidelines. Discussion of the results of e-book accessibility research will be the answer of research question two.

### 3.8.1 Relationship between WCAG 2.0 and UAAG 2.0

An application that contain the end user's interaction with the web content then this type of applications has user agent in it. User agent is responsible to retrieve, extract and accomplished the end user's tasks. If the application has only web content, then developer can set the specified content. There is no need of user agent when there is only web content. Moreover, for both situation web content is present and must be follow accessibility guidelines of WCAG 2.0. UAAG 2.0 user agent accessibility guidelines are check the accessibility in the application like readers, applications, web browsers etc. (Caldwell, Cooper, Reid, & Vanderheiden, 2008) (Allan, Lowney, Patch, & Spellman, 2015).

### 3.8.2 Why WCAG 2.0 for e-book document

Since there are no specific accessibility guidelines to check the electronic documents accessibility. Web content accessibility guidelines provides us how can we design an accessible web page and how can we design the whole accessible website by using these accessibility guidelines. Web page and e-book document have almost same content. Web page contain heading, images, tables, diagrams, visual data, table of contents and many other contents same as e-book content. Hence, research follow the WCAG 2.0 accessibility guidelines for the e-book document. I will test the possible accessibility problems by using the two-testing strategy in research (automated testing and manual testing). Moreover, plan of user testing will also be discussed in the research of e-book accessibility.

### 3.8.3 Why UAAG 2.0 in research

E-book is read by e-readers, online and through other resources. Part of this research has been to check the e-reader's assistive technology by using UAAG 2.0 guidelines. whether the e-readers containing assistive technology and accessible tools according to UAAG 2.0. How UAAG 2.0 can be helpful for the e-readers. What accessibility features should be considered in UAAG 2.0. Whether the e-reader follow the UAAG 2.0 and e-books follow the WCAG 2.0 accessibility guidelines? How both UAAG 2.0 and WCAG 2.0 improve the accessibility in e-books and e-readers.

The purpose to discuss the both guidelines in research is that e-books are read by the e-readers. E-readers and e-books both must be designed according to these accessibility guidelines. UAAG 2.0 is essential because e-books are read through e-reader and end users have the interaction with e-book through e-readers and user agent is responsible to read, extract and accomplished the end-user's tasks or reading task.

### 3.9 User testing

Usability testing is to find out the user's behavior or reaction in some specific task assigned by the testers and evaluators and to observe whether the users are satisfied with their tasks. The usability testing is performed on real users to find out the testing goals. Different testing tasks are assigned to the target group of users and their actions are recorded and observed by the tester and evaluators. The usability testing aim is to find out the problems in a specific or more general way by involving the real users. The tasks are designed by the tester and evaluators. The tasks can be in the form of questionnaires, interviews and testing through some tools (Tüzün, Telli & Alır, 2016).

I wished to conduct the user testing technique after the automated testing and manual testing. The aim of conducting the user testing is to find out the users experience about the e-book reading including good experience and bad experience. Findings of user testing will be to find out more possible accessibility problems in e-books for the blind people and people with low vision. What they want more in e-book document and e-reader in term of accessibility. Unfortunately, due to the time constraint it could not be possible for me to conduct user testing in this research. But, I have some plan of user testing and following are the user testing plan for e-book accessibility research.

#### 3.9.1 User testing plan

1. Writing questionnaires. Questionnaires are about e-book accessibility problems. Questionnaires are designed for the people with low vision. The aim of designing the questionnaires is to find out the user's experience (good and bad experience) about the e-book reading through e-readers. What they want more in e-books document and e-readers accessible tools. Image of questionnaires are shown below.
2. Interviews will be Conducted for the (blind people) about the e-book accessibility issues. Interviews questions will be discussed below.

3. Interviews will be recorded.
4. Questionnaires will be filled by the people with low vision.
5. What the blind users wants in e-book accessibility will also be the part of user testing.
6. Provide more accessibility points for the e-book to the publisher and the developer to achieve the e-book accessibility.

### 3.9.1.1 Questionnaires for the people with low vision

Questionnaires of e-book accessibility problems are for the people with low vision are shown in the picture below. Questionnaire are designed to find out more accessibility problems in e-books and whether the people with low vision are satisfied with the existing accessible tools and what they want more in e-books accessibility. What are their expectations from the developers about more accessible tools in e-books?

## E-book accessibility questionnaires for people with low vision

1. Please rate the following statements regarding E-book accessibility for people with low vision.

|   | Strongly unsatisfied  | Unsatisfied           | Neither Satisfied nor Unsatisfied | Satisfied             | Strongly satisfied    |
|---|-----------------------|-----------------------|-----------------------------------|-----------------------|-----------------------|
| Satisfied with the accessible tools (zoom in, zoom out, Change font style, change font size)          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the Foreground and Background color of e-book  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with accessible tool or customization option of font style, font size, color contrast etc.) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with e-book reading order   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the line length.(short line and long line of words)                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the e-book text (Lower caps, upper caps are customizable)                              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the paragraph in e-books (short paragraph and long paragraph)                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the block of text in e-book (continuous block and multiple columns)                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the images with text. (text is readable in the form of images)                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |
| Satisfied with the rewrap (after zoom in option horizontally scrolling is active or not)              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>             | <input type="radio"/> | <input type="radio"/> |

Figure 3.2 Questionnaire for the people with low vision

2. How much accessible tools help the people with low vision while reading e-books? \*

0 %                       50 %                       100 %

What are the most accessible tools that are used by you while reading e-books?

---

3. Developers should develop more accessible tools for the people with low vision?

Yes     No

What accessible tools recommend you to the developer for the improvement of accessibility?

[Finish Survey](#)

Figure 3.3 Questionnaire for the people with low vision

### 3.9.1.2 Interview questions from the blind people

Moreover, in user testing plan is to conduct the interviews questions for the blind people. Aim of the interview is to find out whether the user is satisfied with the e-book accessibility and what accessibility problems they are facing in e-book reading. Following are the e-book accessibility interview questions for the blind people.

1. Are you satisfied with the e-reader assistive technology (screen reader or text- to-speech software and other screen reading software)?
2. If you are satisfied with the assistive technology provided by the developer in e-reader, then what is the best thing in assistive technology (screen reader).
3. If blind people are not satisfied, then what type of accessibility problems you face when you read the e-book with screen reader?
4. Is screen reader reads the e-book content and screen reader narration speed is fast, medium and low.
5. Screen reader pronunciation of word easily understandable by you?
6. Can you adjust the screen reader settings according to your requirement or need?

7. When you use the screen reader navigation is easy in e-book reading?
8. If navigation is not easy then where the accessibility issue lies. For example, navigation through table of content is not according to your satisfaction. Difficult to navigate forward and backward or e-book pages. Difficult to navigation different links in e-book.
9. Is screen reader reads the alternative text of visual data?
10. Is visual data alternative text being meaningful to you and you understand the images through screen readers and alternative text provided by the author?
11. Is screen reader differentiate the meaning of homophones whenever homophones words came in the e-book text.
12. Is abbreviation is handled by the screen reader? Is screen reader provide the full form of abbreviation and in e-book abbreviation full form is provided by the author?
13. If e-book contain the image in form of text, then the text in the image is readable by the screen reader through the alternative text description.
14. If e-book contain any graph related data, then screen reader reads the graph data and you understand the actual graph by listening to the screen reader?
15. If e-book contain mathematical formulas, then formulas are readable successfully by the screen reader in the e-book?
16. Are you satisfied with the current assistive technology in e-reader and accessible document of the e-books?
17. Do you want more accessibility in e-books and assistive technology and accessible tools in e-readers?
18. How much assistive technology helps you in reading e-books?

## 4. Results

Results are generated in the form of accessibility problems after accompanying the testing techniques that was discussed in the method chapter. Results are in the form of e-books accessibility problems and these accessibility problems are the answer of research question one. Accessibility problems are in e-book document and lack of assistive technology in e-readers. In results chapter, results will be compared according to accessibility guidelines and techniques. Results of e-book document is discussed according to WCAG 2.0 and lack of assistive technology will be discussed according to UAAG 2.0 user agent accessibility guidelines and techniques for the research of e-book accessibility.

Automated testing conducted only in e-book document and manual testing conducted on both e-book and e-readers. When automated testing conducted by EPUB validator the accessibility problems were founded in the form of file. The file contains a very high number of accessibility errors. It will not possible to discuss all the accessibility errors here, but the overall summary of accessibility errors is discussed in EPUB validator section. Moreover, the output file of automated testing EPub validator is attached in the appendix.

According to Chisholm and Henry (2005) compatibility between hardware and software play a vital role in terms of accessibility. The document language, structure, content (text, images, presentation, formatting, styling etc.) must be compatible with readable through user agents and assistive technology. User agents are the tools that provides a better medium to read the e-book document with some assistive technology. For instance, zoom in, zoom out, font style, font size, background and foreground color etc.)

### 4.1 Automated testing results by IBM Bluemix

Following e-book was tested through Bluemix (digital content checker) and EPUB validator.

| E-book                 | Detail of E-book  |
|------------------------|---|
| <b>Treasure Island</b> | Language: English<br>Author: Stevenson, Robert Louis, 1850-1894<br>Subject: Sea Stories, Pirates--Fiction<br>Format: EPUB (with images)<br>Tools: Bluemix, EPUB validator |

*Table 4.1 Book no 1*

While doing automated testing through IBM Bluemix digital content checker common violation descriptions founded and listed below. The count of violation is 195. These Violations are incorporated in many pages of e-book.

Tables shows the violations and potential violations according to their line numbers. Violations and potential violations are e-books accessibilities problems. The listed problems are the answer of research question one from automated testing technique. All the violations in the below tables are taken from the console.bluemix.no.



| Count | Line no | Violation   |
|-------|---------|---|
| 1.    | 10      | “Provide descriptive headings for Web page sections.” (Console.bluemix.net, 2017).                              |
| 2.    | 13      | “Hyperlinks must contain text or an image with alt text.” (Console.bluemix.net, 2017).                          |
| 3.    | 1       | “Html element must have lang and/or xml: lang attribute that conforms to BCP: 47.” (Console.bluemix.net, 2017). |

Table 4.2 Violations from the (console.bluemix.net, 2017).

| Count | Line no | Potential Violation  |
|-------|---------|--|
| 1.    | 2       | “Make sure BLOCKQUOTE is used only for quotations, not indentation.” (Console.bluemix.net, 2017).  |
| 2.    | 30      | “Use proper HTML tags to create lists.” (Console.bluemix.net, 2017).   |
| 3.    | 1       | “If this instance of the word(s) {0} is part of instructions for using page content, ensure the instructions can be understood by a user who may not have sensory perception of size, sound, shape, or location.” (Console.bluemix.net, 2017). |
| 4.    | 1       | “Provide a mechanism to bypass blocks of content that are repeated on multiple Web pages.” (Console.bluemix.net, 2017).  |

Table 4.3 Potential violation from (Console.bluemix.net, 2017).

#### 4.1.1 Results explanation violations explanation

Following are the accessibility problems in tested e-book from the automated testing technique. The result explanation is taken from the console.bluemix.no. Each result is explained with the

WCAG 2.0 accessibility guidelines and techniques. Testing by Bluemix digital content checker check the e-book accessibility according to WCAG 2.0 accessibility guidelines and techniques.

#### *4.1.1.1 Problem 1: Heading without description*

In tested e-book headings have no proper descriptions. Moreover, headings are inaccessible for blind people and other screen reader users. “The heading of each section identifies the subject of the section and make sense when read out loud by a screen reader. Heading description must be according to its content and meaningful. The heading description should not be empty. Moreover, heading description help the users to find the specific content within the web page or digital document. Use proper heading styles h1 to h6 to identify the heading. Most screen readers allow users to quickly jump between headings; the use of well-placed, descriptive headings improves a user's ability to navigate the page and understand the content.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.6).

#### *4.1.1.2 Problem 2: Some links are inaccessible for the blind people*

In tested e-book, there are many links found without alternative text. “Assistive technologies must be able to gather information about user interface controls in page content. Without this information, users are unable to determine the purpose of a link. Use text within the <a> element, or the 'alt' attribute on an image of the link to convey this information to users. Some web authors use a technique where they provide an accessible name for the <a> element with the 'title' attribute, and they style the element with a CSS background image. This technique may not be accessible to low-vision users. When high-contrast mode is active (Alt+Shift+PrtSc), background images are not displayed; therefore, these links disappear from the page.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.4).

#### *4.1.1.3 Problem 3: There is no language attribute*

There is no default lang attribute found in tested e-book. “Identify the default language of the document by providing the lang or xml: lang attribute on the HTML (Hyper Text Markup language) element. Some text- to speech software and screen readers uses multiple languages so language attribute helps to identify the language of the document e.g. < html lang = “en” > defines that document language is in English.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 3.1.1).

#### *4.1.1.4 Problem 4: Improper formatted*

In tested e-book, there is no proper formatting of document that create difficulty to navigate the e-book content properly. “Do not use Q and BLOCKQUOTE for formatting effects such as indentation. Organization of the page is very important, and it also help to understand the assistive technology like text-to speech software and screen readers to navigate the page content “(Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 3.2.3).

#### *4.1.1.5 Problem 5: List is not created properly*

List is not treated as a list and screen reader just read the list as a simple text in tested e-book. “Do not use visual formatting to make text appear to the user as a list. Always use appropriate HTML tags to create the list. It will be more readable by the screen reader users.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.3.1).

#### *4.1.1.6 Problem 6: Visual elements are not accessible*

Some visual effects are found in tested in e-books. “Visual elements in the document are meaningless for those who have some sighted problem. Adding label, additional text may not help them to understand the visual elements.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.1.1).

#### ***4.1.1.7 Problem 7: Usage of blocks creates navigation problems***

“Use links to skip blocks of repeated content, or group blocks of repeated content in a way that can be skipped.” (Console.bluemix.net, 2017) (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.1).

## **4.2 Automated testing results by EPUB validator**

While doing automated testing through EPUB validator. Many accessibility problems are found in different lines of e-books. The count of accessibility problems was very high. It will be very difficult to discuss all the problems here. After automated testing through EPUB validator one file is generated that contain error, error type, line no, position of error and error message. Error message are in form of hypertext markup language (html) code. The file is attached in the appendix.

EPUB validator checks accessibility problems in each line of e-book with error position. Mostly accessibility problems are format issues, language attributes aren't properly defined alternative text is missing, title is not defined.

## **4.3 Advantage and disadvantage of automated testing tools**

There are many positive points of testing the accessibility by online automated tools. Many online tools are available to check the accessibility of web pages, pdf files, e-books and another electronic document. Through automated tools, testers found lot of accessibility problems and suggestions. Suggestions provide the guidelines to overcome the accessibility problems.

Automated accessibility tools are affordable and provides quick result. The result of automated testing tools is in the form of file contains line number, position and path of the error and the proper description of the accessibility errors. The most important thing of online automated tools are they tested every page of the book. Size doesn't matter while checking the accessibility in the electronic document through online accessibility tools. On the contrary, there are some negative points as well. Firstly, tester don't believe on online accessibility tools because these online accessibility tools doesn't identify every accessibility issue in every page of the document. Lot of accessibility issues are ignored by these online automated tools. To check every aspect of accessibility manual testing is conducted but it is time consuming and lot of concentration is required to perform manual testing (Duran, n.d.).

#### 4.4 Comparison of automated tool EPUB validator and Digital content checker by Bluemix

Both online tools Digital Content Checker by Bluemix and EPUB validator checks the accessibility errors in e-book in this research of e-book accessibility.

1. EPUB validator identified more accessibility errors than the digital content checker. The count of errors in EPUB validator is higher than digital content checker by Bluemix.
2. Each accessibility problems found in digital content checker by Bluemix are linked to WCAG 2.0 accessibility guidelines and technique. Further, success criteria of errors are discussed that help to determine the accessibility features. On the other hand, EPUB validator errors report just contain the error position, line number of the document in which error exist. Description of error according to WCAG 2.0 accessibility guidelines are not found in the result.
3. Testing results of digital content checker by Bluemix are associated with WCAG 2.0 accessibility guidelines and techniques. In other words, testing result clearly linked with WCAG 2.0 and provide clear description of how document should be designed according to accessibility guidelines and technique. On the other hand, EPUB validator validates the e-book in term of accessibility but result doesn't provide a clear description of accessibility problems and there is no link of problems with WCAG 2.0 accessibility guidelines and technique.

## 4.5 Results of manual testing for e-book 1

Following are the results of manual testing conducted by voiceover screen reader on iBooks e-reader app on MacBook pro.

| E-book                 | Detail of E-book                             |
|------------------------|--|
| <b>Treasure Island</b> | E-reader: iBooks<br>Screen reader: Voiceover |

*Table 4.4 E-book no 1*

### 4.5.1 Test case 1

There is no proper structure for heading, sub heading and section heading. Font style is not same. For instance, table of contents contain italic style and font color is not appropriate according to accessible document. The font of the book is Calibri (Body) with 12 font size, but in quotation part the font style is change. Line spacing is 1.0 all the text is left aligned. Proper page numbering is found and readable by screen reader. Header and footer are found in the e-book but is not readable by the screen reader. An accessible document must contain the contents that should be readable by screen reader so that accessibility can be achieved. In addition, the font color is light blue in table of content is not accessible as well as images found in the e-book is not inline according to its text description. Mostly images have no alternative text and if some images found with alternative text then there is no meaningful text. For instance, alternative text of one image is "image002", and it is meaningless and alternative text should describe the image with a proper descriptive text.

#### *4.5.1.1 E-reader assistive technology*

The reading through screen reader is quite good. iBooks application provides different utility options (assistive technology and accessible tools). Screen reader voiceover is used to read the e-books in iBooks application. User can adjust the screen reader voiceover speed according to their need. Reading word to word, line to line, one sentence, one paragraph and whole page is possible through voiceover screen reader. However, it is the reader choice which option he/she is choose while reading through screen reader. Some important contents found in the e-book that was not readable by the screen reader due to lack of accessibility options or inaccessible document. For instance, e-book document is inaccessible, that's why screen reader unable to read the content. In the e-book, it is found that footer part is not readable by the voiceover screen reader. In other word, footer part is not designed according to accessibility guidelines in the e-book document. Footer contain back to previous page; how many pages are left in the book and page number is inserted in the middle of the e-book. Screen reader reads the page number, but other contents are not readable by the screen reader.

#### *4.5.1.2 E-book document*

Paragraph spacing and line spacing are not according to accessible document. In the e-book document, foreground and background color change option is not available. Besides the assistive technology, there should be some extra options to the low vision to adjust the setting according to their need of demand in the e-book document. In addition, to change the font size and style of the e-book document there is no option and button founded in the e-book. Text were not justified in e-book document.

#### **4.5.2 Test case 2**

E-reader (iBooks application) assistive technology (voiceover) ignored the abbreviations. Screen reader (voiceover) reads the abbreviation as a word. There is no extra information or full form of abbreviation found in the e-book document as well. Both iBooks applications or voiceover screen reader and e-book document are highly inaccessible and ignored the abbreviation. It creates problems to understand between the actual word and abbreviations to the blind people and other screen reader users.

#### *4.5.2.1 E-reader assistive technology*

While conducting manual testing, many abbreviations in the e-book text are incorporated. Screen reader reads the abbreviation in the same as the word. Screen reader treated the abbreviation without its meaning and purpose. There is no extra information provided by the iBooks application against the abbreviation. Hence, lack of assistive technology found in iBook application (e-reader) during the manual testing of e-book accessibility research.

#### *4.5.2.2 E-book document*

No full form of abbreviation is found in the e-book document as well. E-book document found inaccessible in the case of abbreviation.

### **4.5.3 Test case 3**

Many homophones words are found in the e-book during testing.

#### *4.5.3.1 E-reader assistive technology*



Screen reader voiceover doesn't provide the homophones words description for the blind people and other screen reader users. Moreover, iBooks application doesn't provide the assistive technology that treated homophones words in the e-book document. Some words who have same pronunciation, but the meaning is different problem may create for blind users to understand the words in the e-book document. Hence, another lacking assistive technology found in iBook application.

#### *4.5.3.2 E-book document*

No homophones description is found in the e-book document as well. Hence, inaccessible document doesn't handle the homophones words for the blind people and other screen reader users.

#### **4.5.4 Test case 4**

There are lot of narrative words like question mark, exclamation mark, quotation marks, full stop, comma, direct and indirect narration, etc. found in e-book during testing e-book document. Screen reader reads the text aloud without the meaning of narrative words. Screen reader reads it like a simple sentence and ignore all the direct and indirect speech in the e-book text.

#### *4.5.4.1 E-reader assistive technology*

Screen reader (voice over) read all the text without taking pause and punctuations expression like question mark, exclamation mark, quotation mark and direct sentence or indirect sentence. Question sentences, direct sentences, sentences that create some special aspects and create some good feelings (through quotations writers' good mood in reading is determined) are ignored by screen reader voice over.

#### *4.5.4.2 E-book document*

During manual testing lot of punctuation marks are found in e-book document.

#### 4.5.5 Test case 5

To check the navigation is easy and determine whether the blind people easily do a navigation from the e-book content through voiceover screen reader. Literature review about navigation is claimed that if the user is aware of using the keyboard and have a lot of command to every key in the keyboard can easily navigate the content of the e-book document.

##### *4.5.5.1 E-reader assistive technology*

While using the voice over screen reader in manual testing, the navigation is fine. No error is found to navigate the content of the e-book. Voice over easily navigate each content of the e-book including label, images, header and footer, pages of the book, text of e-book, sentence, word, end notes and many other contents of the book document. The result seems that voice over screen reader is very user friendly and easily navigable through voice over command.

##### *4.5.5.2 E-book document*

In e-book table of content is not properly designed and links of each chapter in e-book are without alternative text option and screen reader read the links of chapter as simple text. The information is incomplete and often provide meaningless information to the blind people and other screen reader users. It is found that, table of content and another e-book content in e-book

document are highly inaccessible and not designed according to accessible guidelines and techniques.

#### 4.5.6 Test case 6

iBooks application provides an accessible tool that increased the font size for the people with low vision and people with other disability as well. Accessibility option of searching the particular content from the e-book also provide the notes option for the people. People can add notes in the e-book document as well. This accessibility option of writing notes inside the e-book document are very helpful for the students when they read the e-books and make the notes of every chapter.

##### *4.5.6.1 E-reader assistive technology*

iBook app provides the accessible tool with different accessibility features for the low vision people as well other people with disability. People with low vision can adjust the foreground and background color according to their need of demand. Moreover, font resize, bookmarks, searching bar accessible tools are provided to make the access easier for the people including people with low vision.

##### *4.5.6.2 E-book document*

There is no separate option inside the e-book document founded e.g. font adjustable option (font resize, font style), and color contrast option.

#### 4.5.7 Test case 7

##### *4.5.7.1 E-reader assistive technology*

iBook application provides the accessible tools for change the color contrast to the people with low vision and easily adjustable the color contrast according to foreground and background color adjustable option. Font size, font type is also adjustable according to the user need to achieve the accessibility. Following image shows the accessible tool of the iBook e-application and captured from the Mac book pro.

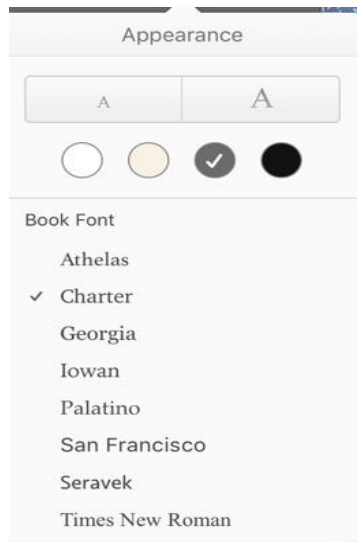


Figure 4.1 Accessible tools for the people with disability (people with low vision) from mac book pro

#### 4.5.7.2 E-book document

Color contrast (background color is white and font color is black), font size is normal. No blinking and moving text were found in the e-book.

#### 4.5.8 Test case 8

##### 4.5.8.1 E-reader assistive technology

Screen reader voice over reads the alternative text description of the image, label, link, hyperlink, table.

#### *4.5.8.2 E-book document*

E-book contain lot of images and there is no alternative text or description in the image is provided by the author of the e-book. In the document, image description is provided. Image name is also very undefined name like 0001.jpg etc. however, there is no diagram, shapes are found in the tested e-book. The alternative text of the images is not understandable. In other words, alternative text of the images is meaningless and doesn't provide the full information of the images and it will create a problem to the blind people and other screen reader users.

#### 4.5.9 Test case 9

##### *4.5.9.1 E-reader assistive technology*

There is no graphical data found in the e-book. Many images found in the e-book with some text description.

##### *4.5.9.2 E-book document*

There is no graphical data, signs, shapes, table, blinking images and diagram found in the e-book. However, some images are found in the start of each chapter without alternative text description. Images found in the e-book are not inline according to their text.

#### 4.5.10 Test case 10

#### **4.5.10.1**      *E-reader assistive technology*

Reading order play a vital role in navigation. Reading order helps to navigate the book content easily and make the reading more efficient and attractive. A good reading order also create the feasibility to the blind people and other screen reader users as well to navigate the content via some assistive technology more efficiently as compared to improper reading order. In the tested e-book, reading order is good. However, e-reader doesn't provide an accessible tool that contain different reading order options and user can select the reading order according to their need of demand. Hence, one more lack of assistive technology found in iBooks applications.

#### **4.5.10.2**      *E-book document*

Table of content contains a proper reading order in a linear way. However, there is no table found in the e-book. Paragraph, sentences are in proper order. Moreover, in e-book there is no option found that change the improper reading order to accessible reading order and create feasibility for the blind people and screen reader users to navigate the e-book content via assistive technology.

#### **4.5.11** Test case 11

No table found.

#### **4.5.11.1**      *E-reader assistive technology*

There is no table found in the e-book document.

#### 4.5.11.2 *E-book document*

No table found in the e-book document.

#### 4.5.12 Test case 12

##### 4.5.12.1 *E-reader assistive technology*

A lot of images found during testing of e-book that contain text in the form of images. Following image found in the e-book are the example of text in the form of image. No meaningful alternative text for images found in the e-book. Text in the form of images are highly inaccessible for the blind people and other people who uses screen reader as well. Screen reader is unable to read the content of the picture as well as there is no alternative text found that explain the text in the picture.

## ILLUSTRATIONS

JUST BEFORE HIM TOM LAY MOTIONLESS UPON THE SWORD . . .  
"I'M FOOR BEN GUNN, I AM. MAROONED THREE YEARS AGONE,  
AND LIVED ON GOATS SINCE THEN" . . . . .  
"DOWN, DOG!" CRIES THE CAPTAIN. AND THE HEAD POPPED  
BACK AGAIN . . . . .  
"TELL US, SQUIRE, WHEN YOU SEE THE MATCH, AND WE'LL  
HOLD WATER" . . . . .  
I RAN TO THE DOOR IN TIME TO SEE JIM HAWKINS, SAFE AND  
SOUND, COME CLIMBING OVER THE STOCKADE . . . . .  
WE BURIED OLD TOM IN THE SAND, AND STOOD ROUND HIM  
BAREHEADED IN THE BREEZE . . . . .  
"GIVE ME A HAND UP!" HE CRIED. "NOT I," RETURNED THE  
CAPTAIN . . . . .  
THE BOARDERS SWARMED OVER THE FENCE LIKE MONKEYS . .  
I LIFTED THE SIDE OF THE TENT, AND THERE WAS BEN GUNN'S  
BOAT . . . . .  
IT SHOWED ME HANDS AND HIS COMPANION LOCKED TOGETHER  
IN DEADLY WRESTLE . . . . .  
I FELT WILLING RATHER TO STARVE AT SEA THAN TO CONFRONT  
SUCH PERILS . . . . .  
"I CAN'T HAVE THESE COLORS, MR. HANDS, AND, BY YOUR  
LEAVE, I'LL STRIKE 'EM" . . . . .  
THE COXSWAIN LOOSED HIS GRASP UPON THE SHROUDS AND  
PLUNGED HEAD FIRST INTO THE WATER . . . . .  
WITH MY ARMS BEFORE ME I WALKED STEADILY IN . . . .  
"TAKE A CUTLASS, HIM THAT DARES, AND I'LL SEE THE COLOR  
OF HIS INSIDE, CRUTCH AND ALL, BEFORE THAT PIPE'S  
EMPTY" . . . . .  
I SAW THE BLADE OF AN OPEN KNIFE SHINE IN HIS HAND . .  
"ONE JUMP AND YOU'RE OUT, AND WE'LL RUN FOR IT LIKE  
ANTELOPES" . . . . .  
FOR ALL THE WORLD, I WAS LED LIKE A DANCING BEAR . . .  
"DARBY M'GRAW!" IT WAILED, "DARBY M'GRAW!" . . . . .  
MERRY TUMBLED HEAD FOREMOST INTO THE EXCAVATION . .  
I WAS KEPT BUSY PACKING THE MINTED MONEY INTO BREAD-  
BAGS . . . . .

Figure 4.2 Image in the form of text.



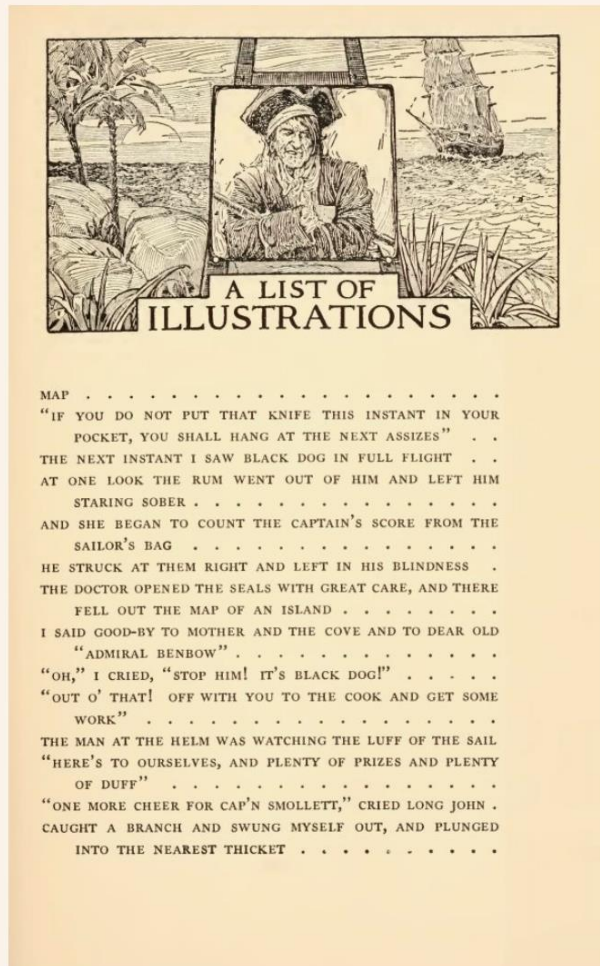


Figure 4.3 Image in the form of text

#### 4.5.12.2 E-book document

During testing of e-book, images found that contain the text in it, but images are in the form of text are not designed according to accessibility guideline and technique for the people with disability.

## 4.6 Results of manual testing for e-book 2

Following are the results of manual testing with kindle e-reader and NVDA screen reader. The e-book no two doesn't contain the different headings like e-book 1. E-reader and e-book results are explained in one heading.

|                                |                     |
|--------------------------------|---------------------|
| E-book                         | Detail of E-book    |
| <b>The legends of Iroquois</b> | E-reader: Kindle    |
|                                | Screen reader: NVDA |

*Table 4.5 E-book no 2 with kindle e-reader*

### 4.6.1 Test case 1

In e-book images are found but some images are without alternative text and some images have meaningless alternative text. Table of content is poorly designed in the table. Table is inaccessible. A lot of text is found in the e-book with many punctuation marks. Headings are found but there is no section heading in the e-book document.

Screen reader skip the table of content, images, some link references. Following image shows the source code of the image and highlighted text shows that alternative text is empty in the images.

```
118
119
120 <hr class="chap" />
121
122 <p class="center"><i>This is one of an edition of 500 copies printed
123 October, 1902, of which this is number</i></p>
124
125 <hr class="chap" />
126
127 <h1 class="pmt4 pmb4"><i>The Legends of the Iroquois</i></h1>
128
129 <hr class="chap" />
130
131 <p><span class="pagenum"><a name="Page_1" id="Page_1">* 1 *</a><br /><a name="Page_2" id="Page_2">* 2 *</a></span></p>
132
133 <div class="fig_center" style="width: 481px;">
134 <a href="images/cornplanter_lg.png"></a>
135 <div class="smaller silver">Click on image to view larger size.</div>
136 </div>
137
138 <hr class="chap" />
139
140 <p><span class="pagenum"><a name="Page_3" id="Page_3">* 3 *</a></span></p>
141
142 <div class="bbox" style="width: 500px; margin: 16px auto;">
143 <div class="bbox" style="width: 450px; margin: 16px auto;">
144
145
146
147 <p class="caption1"><i>The Legends of the<br />
148 Iroquois</i></p>
149
150 <p class="caption3 pmb2">TOLD BY "THE CORNPLANTER"</p>
151
152 <hr class="r20" />
153
```

Figure 4.4 Image without alternative text

#### 4.6.2 Test case 2

No abbreviation is found in the e-book document. Kindle e-reader app doesn't provide extra information of abbreviation in the e-book document.

#### 4.6.3 Test case 3

There is no homophones word description found in the e-book document as well as Kindle e-reader app.

#### 4.6.4 Test case 4

Punctuation mark and quotation marks are found in the e-book document. NVDA pronunciation through reading of text is good. Screen reader takes pauses and breaks while reading the text. However, some quotation marks in the sentences are ignored by the screen reader.

#### 4.6.5 Test case 5

The e-book layout is not designed according to accessible guidelines and technique for the people with disability. Table of content is referenced only with number. Table of content is designed in the table. Table is highly inaccessible and is not designed according to accessibility guidelines and techniques. For instance, during testing it is found that table have no header row, no title and without caption. Table of content found also without alternative text. The following image are the table of content. First image is taken by the e-book document during testing. Second image is the source code of the table of content and shows that the table design is highly inaccessible for the blind people and people with other disability as well.

Bookmarks People Window Help

+

erg.org/files/58228/58228-h/58228-h.htm

### *Contents*

|                                   |                     |
|-----------------------------------|---------------------|
| About Indian Legends              | <a href="#">9</a>   |
| The Authority                     | <a href="#">15</a>  |
| The Confederation of the Iroquois | <a href="#">23</a>  |
| Birth of the Arbutus              | <a href="#">41</a>  |
| A Legend of the River             | <a href="#">47</a>  |
| Legends of the Corn               | <a href="#">51</a>  |
| The First Winter                  | <a href="#">55</a>  |
| The Great Mosquito                | <a href="#">59</a>  |
| The Story of Oniata               | <a href="#">63</a>  |
| The Mirror in the Water           | <a href="#">73</a>  |
| The Buzzard's Covering            | <a href="#">77</a>  |
| Origin of the Violet              | <a href="#">81</a>  |
| The Turtle Clan                   | <a href="#">85</a>  |
| The Healing Waters                | <a href="#">89</a>  |
| The Sacrifice of Aliquipiso       | <a href="#">99</a>  |
| Why the Animals do not Talk       | <a href="#">103</a> |
| The Message Bearers               | <a href="#">119</a> |
| The Wise Sachem's Gift            | <a href="#">123</a> |
| The Flying Head                   | <a href="#">125</a> |
| The Ash Tree                      | <a href="#">127</a> |
| The Hunter                        | <a href="#">129</a> |
| Hiawatha                          | <a href="#">137</a> |
| The Peacemaker                    | <a href="#">149</a> |
| An Unwelcome Visitor              | <a href="#">155</a> |
| Bits of Folk-Lore                 | <a href="#">161</a> |
| The Happy Hunting-Grounds         | <a href="#">169</a> |
| The Sacred Stone of the Oneidas   | <a href="#">187</a> |
| Notes to the Legends              | <a href="#">197</a> |

Figure 4.5 Table of content (inaccessible e-book content)

```
192 <h2><a name="Contents" id="Contents"><i>Contents</i></a></h2>
193
194 <table style="width: 30em; summary="TOC">
195 <tr class="row1">
196 <td class="td1">About Indian Legends</td>
197 <td class="tdr"><a href="#ABOUT_INDIAN_LEGENDS">9</a></td>
198 </tr>
199 <tr>
200 <td class="td1">The Authority</td>
201 <td class="tdr"><a href="#THE_AUTHORITY">15</a></td>
202 </tr>
203 <tr class="row1">
204 <td class="td1">The Confederation of the Iroquois</td>
205 <td class="tdr"><a href="#THE_CONFEDERATION_OF_THE">23</a></td>
206 </tr>
207 <tr>
208 <td class="td1">Birth of the Arbutus</td>
209 <td class="tdr"><a href="#BIRTH_OF_THE_ARBUTUS">41</a></td>
210 </tr>
211 <tr class="row1">
212 <td class="td1">A Legend of the River</td>
213 <td class="tdr"><a href="#A_LEGEND_OF_THE_RIVER">47</a></td>
214 </tr>
215 <tr>
216 <td class="td1">Legends of the Corn</td>
217 <td class="tdr"><a href="#LEGENDS_OF_THE_CORN">51</a></td>
218 </tr>
219 <tr class="row1">
220 <td class="td1">The First Winter</td>
221 <td class="tdr"><a href="#THE_FIRST_WINTER">55</a></td>
222 </tr>
223 </tr>
```

Figure 4.6 Source view code for the table of content

#### 4.6.6 Test case 6

Kindle e-reader provide different accessible tools for the people with low vision and other people with disability as well like zoom in, zoom out, font style, font size, searching, alignment, line spacing, page width, brightness and color mode. There is no extra button found inside in e-book document that handle some accessibility features belongs to people with low vision and people with other disability as well in the e-book document.

#### 4.6.7 Test case 7

There is no extra option of font style found in the e-book document. However, kindle e-reader provide different accessible tools of font (style, font size, color etc.)

#### 4.6.8 Test case 8

There are very a smaller number of images found in the e-book and some has no alternative text, and some has meaningless alternative text. However, there is no shapes, homophones, abbreviation, diagram, label are found in the e-book document.

#### 4.6.9 Test case 9

No statistical data e.g. charts, graphs, diagrams, mathematical formulas, mathematical expressions are found in the e-book.

#### 4.6.10 Test case 10

The e-book has no proper reading order and that's why navigation becomes difficult through screen reader for the blind people and people with other disabilities as well. Table of content is not navigable by screen reader and designed very poorly. Table of contents are not designed according to accessibility guidelines and techniques in the e-book document.

#### 4.6.11 Test case 11

One table is found in the e-book and that is inaccessible for the blind people and other screen reader users as well. Navigation in the table is not done by the screen reader, because table is not designed according to accessibility guidelines and techniques.

#### 4.6.12 Test case 12

E-book has images with text and that are highly inaccessible without alternative text. Screen reader ignore the images because there is no alternative text are provided by the author. The images in e-book are not designed according to accessibility guidelines and techniques.

## 4.7 Results of manual testing for the e-book 3

Following are the results of manual testing with voiceover screen reader and iBooks application of e-book number 3. Following e-book contain many formulas, equations, diagram, graphs and images. The purpose to conduct the manual testing for the mathematical type books is to know that the blind students are able to read the formulas, equations, graphs through the screen reader in e-books. Results explanation are discussed below.

|                               |                              |
|-------------------------------|------------------------------|
| E-book                        | Detail of E-book             |
| <b>Advanced algebra ii</b>    | E-reader: iBooks application |
| <b>Conceptual explanation</b> | Screen reader: Voiceover     |

*Table 4.6 E-book no 3*

1. The tested e-book contains a title, headings, sub headings, links, labels, many mathematical or algebraic expressions, graphs, logarithm, images and figures. Some of the content of tested e-book is accessible and some content of the e-book is inaccessible. For example, links are found in the e-book and these links are highly inaccessible there is no alternative text of the link are defined in the source code. Whenever, the link appeared voice over read "link". There is no extra description of the link found in the e-book document.
2. Headings are designed according to the different heading level. All the headings are accessibly designed according to their heading level h1, h2 and h3. Background color of the tested e-book is black and font color is white.
3. Page number is readable by the screen reader and accessibly designed. Reading order is accessible and easily navigable by the screen reader (voiceover).



4. Bullets and numberings are used to define the list in the e-book document. Table of content is accessibly designed.

5. Many mathematical expressions found in the e-book document like  $F(x)$  and screen reader read it like  $Fx$  and screen reader exclude the parenthesis. Some fractions numbers and formulas are found in the e-book document in the form of images. And formulas and fractional number are highly inaccessible for the blind people and other screen reader users. Following images of formulas and fraction are below and font color black indicates the inaccessible image of formula in the image. Font color black formulas and fractional numbers are inserted in the table are inaccessible design (without the meaningful alternative text).

unit will be an exploration of logarithms.

### A few quick examples to start things off

Table 6.1.

| Problem                                | Means                                 | The answer is             | because                                    |
|--|---------------------------------------|---------------------------|--|
| $\log_2 8$                             | 2 to what power is 8?                 | 3                         | $2^3$ is 8                                 |
| $\log_2 16$                            | 2 to what power is 16?                | 4                         | $2^4$ is 16                                |
| $\log_2 10$                            | 2 to what power is 10?                | somewhere between 3 and 4 | $2^3 = 8$ and $2^4 = 16$                   |
| $\log_8 2$                             | 8 to what power is 2?                 | $\frac{1}{3}$             | $8^{\frac{1}{3}} = \sqrt[3]{8} = 2$        |
| $\log_{10} 10,000$                     | 10 to what power is 10,000?           | 4                         | $10^4 = 10,000$                            |
| $\log_{10} \left(\frac{1}{100}\right)$ | 10 to what power is $\frac{1}{100}$ ? | -2                        | $10^{-2} = \frac{1}{10^2} = \frac{1}{100}$ |
| $\log_5 0$                             | 5 to what power is 0?                 | There is no answer        | something will never be 0                  |

As you can see, one of the most important parts of finding logarithms is being very familiar with how exponents work!

Figure 4.7 Formulas in the form of image

## 1.3. What is a Function?\*

A function is neither a number nor a variable: it is a **process for turning one number into another**. For instance, “Double and then add 6” is a function. If you put 4 into that function, it comes out with a 14. If you put a  $\frac{1}{2}$  into that function, it comes out with a 7.

The traditional image of a function is a machine, with a slot on one side where numbers go in and a slot on the other side where numbers come out.

Table 1.1. A number goes in. A number comes out. The function is the machine, the process that turns 4 into 14 or 5 into 16 or 100 into 206.

5 →  → 16

Figure 4.8 inaccessible fractional image

6. On the hand, some figures are found that contain alternative text and alternative text is meaningful to the blind people and screen reader users. Following are the figures of the graphs with a proper alternative text description.

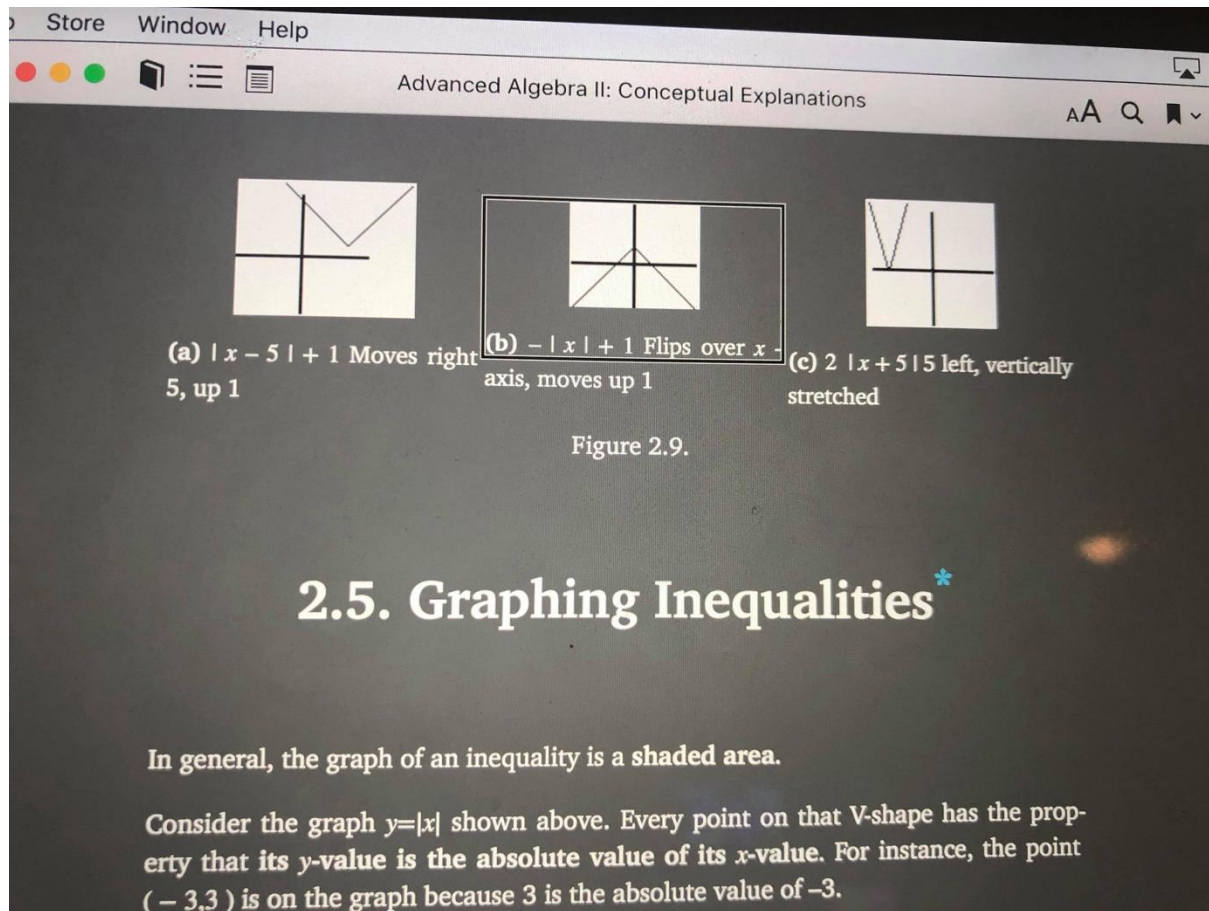


Figure 4.9 Accessible graphs with an alternative text

7. Arithmetic operator like  $+$ ,  $-$ ,  $*$ ,  $=$  are readable by the screen reader. But some operators are skipped by the screen reader. For instance, square of  $x$  is read like  $x^2$  instead of  $x$  square  $n$ . And logarithm values(base) are also not readable by the screen reader and screen reader read it as  $\log 2 x$  instead of  $\log$  base 2 of a number  $x$ .

8. Some images are found in the e-book document that contain meaningful alternative text for the blind people and screen reader users. Following image contain a meaningful alternative text. However, on the right side of the image, some functions are used, and these functions are in the form of image and image alternative text doesn't describe the functions. On the left side image of gear is displayed, and this image is accessible with a meaningful alternative text description.

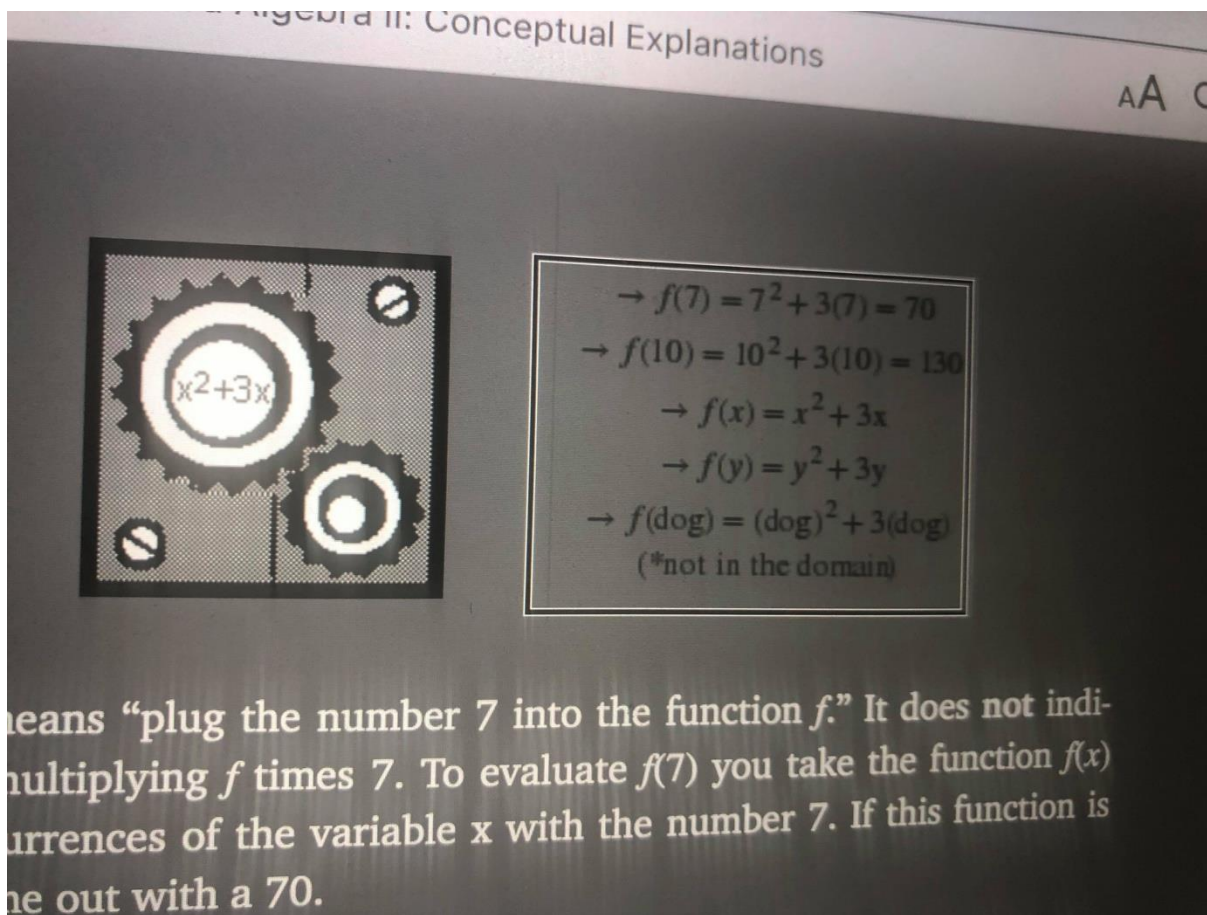


Figure 4.10 right side functions image is inaccessible, left side gear image is accessible

9. Many tables are found in the e-book document and tables are inaccessible for the blind people and screen reader users. All the images, figures are inserted in the table. There is no header row defined in the table. Hence, tables are highly inaccessible for the blind people and other screen reader users.

10. Some metrics are found in the form or image in the e-book document. Through alternative text description metrics are accessible for the blind people and screen reader users. Alternative text describes the metrics. Following image are the example of metrics in the form of image.



... items, and the third items, and so on. Finally, you add all the items to get the final number.

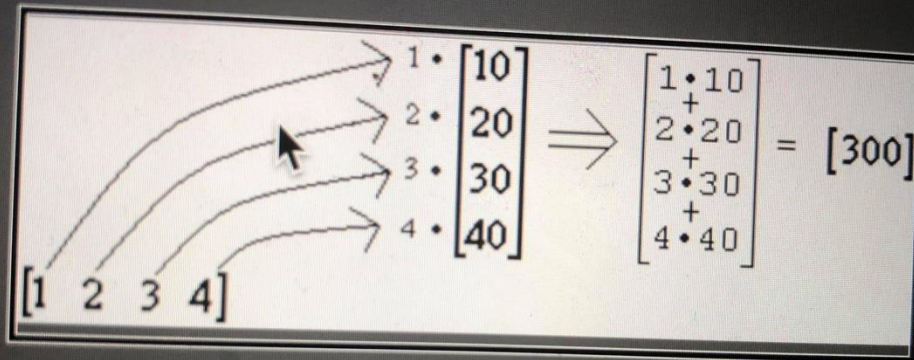


Figure 10.1.

... students (Nakisa Asefnia and Laura Parks) came up with a way of visualizing this process. Think of the row as a dump truck and the column as a dumpster. When the row dumps its load, the number of items in the column increases by the number of items in the row. Like so:

Figure 4.11 metrics in the form of image

Hence, different e-books are tested to check the accessibility for the blind people and people with low vision. Some e-book content found accessible and some e-book content is highly inaccessible for the blind people and people with low vision. No e-book is found that contain whole accessible e-book content for the blind people and people with low vision.

## 5. Discussion

In the discussion chapter, results will be discussed according to WCAG 2.0 accessibility guidelines and techniques and UAAG 2.0 user agent accessibility guidelines. WCAG 2.0 accessibility guidelines will improve the accessibility for the e-book document and UAAG 2.0 user agent accessibility guidelines will provides some assistive technology for the e-readers to answer the research question two. After the results discussion with WCAG 2.0 and UAAG 2.0, suggestions and recommendations of an accessible e-book document is provided by me to the publishers and programmers with the help of WCAG 2.0 web content accessibility guidelines and techniques and UAAG 2.0 user agent accessibility guideline and technique. Limitations of the e-book accessibility research and future work of e-book accessibility research will also be discussed in this chapter. During testing, some common accessibility problems found in e-books that is discussed only one time in discussion chapter, but accessibility problems are listed according to their e-book in result chapter.

### 5.1 Result discussion of automated testing

Accessibility problems found after automated testing by Bluemix digital content checker is discussed below. Problems will be discussed according to the accessibility guidelines and technique. Discussion of each problem consist of two part. First, testing result will be discussed according to WCAG 2.0 accessibility guidelines and technique. Second, if testing result is about accessible tools and assistive technology of e-reader then UAAG 2.0 user agent accessibility guidelines and techniques will be discussed and otherwise UAAG 2.0 accessibility guidelines will be skipped.

#### 5.1.1 Problem 1: heading without description

Headings, section headings and title in the document plays a very important role in the e-book document. According to WCAG 2.0 accessibility guidelines and techniques the layout of digital

document must follow an accessible reading structure or an accessible layout. Headings, sub headings and title of the e-book help the blind people and other people who use screen reader while reading e-books, because navigation became very easily if e-book document is an accessible structure with a proper heading, sub heading and title description. Title, headings, sub headings are the supplementary information provided by the author in the e-book document to the people and people with disability to understand the e-book content. Structure of the e-book document easily navigable by the assistive technology (screen readers) and understandable to the screen reader users as well (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.6).

According to UAAG 2.0 user agent accessibility guidelines and technique when there is no heading description, label alternative text and other alternative description is missing then e-reader should contain assistive technology that use metadata against the heading, images and label. If e-book document is missed some heading description, alternative text then assistive technology provides something to the users that is equivalent to that information e.g. that is heading or that is image by providing some repair text. (Allan, Lowney, Patch, & Spellman, 2015, success criteria 1.1.2).

The purpose of heading and title description is to help the blind people to find the information on the pages (web and e-book page). Descriptive heading and title help to understand the page information more clearly as well as descriptive label help to understand the different content of the web page and e-books pages. Heading, title and labels description must not be longer than word. Description should be in one word or single character that help the blind people and other screen reader users to navigate the content easily (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.6).

Hence, to achieve the accessibility then any page of the e-book and web page have heading and title it must be clearly defined. Write the description of each heading and title by using the title

element and heading tag. Section of each heading in every page also be clearly defined to make the document accessible.

### 5.1.2 Problem 2: inaccessible links and images without alternative text are inaccessible for the blind people

The alternative text is very important in the visual data as well as links and hyperlinks. Through alternative text, e-readers assistive technology helps the blind people and screen reader users to read the visual data. For instance, if alternative text is defined by the author in the e-book against the visual data, then screen reader can read the alternative text to the blind people and other people who uses screen reader to understand the visual data. Alternative text makes the accessibility to the people with disability. Similarly, hyperlinked should also contain the alternative text. Hyperlinked can be any form e.g. hyperlink may be in the form of image then alternative description of the images is clearly defined by the author to make it accessible for the people with disability especially for the screen reader users. Moreover, if the hyperlinked is in both image and text form then one option of alternative text can be chosen to make the link accessible. (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.1.1,2.1.1,2.4.4,2.4.9,4.1.2).

As we discussed in problem one according to UAAG 2.0 user agent accessibility guidelines provide assistive technology to the user who use screen reader if there is some missing information in the document. The purpose of defining the hyperlink alternative text is to provide the enough information to blind people and users who use screen reader to insure compatibility and easily go to one page to another page (Allan, Lowney, Patch, & Spellman, 2015, success criteria 1.1.2).

Hence, all non-text content, images with links, hyperlink, label, table, diagram, shapes and other data must contain the alternative text. Alternative text should be meaningful text. Meaningful alternative text helps the blind people and other screen reader users to navigate the e-book



content easily. Further, the alternative link must contain text that is meaningful and easily understandable to its users and the hyperlink purpose must also be clearly defined.

### 5.1.3 Problem 3: there is no language attribute

According to WCAG 2.0 success criteria, the lang attribute of the document is very essential, because through “lang” attribute language of the document is determined. E-readers assistive technology (screen reader) contain multiple languages and people can select the language according to their choices. The whole document contains one language including reference label. For instance, if the user selects French language then every text of the e-book should be in French language including reference label (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 3.1.1).

According to the UAAG 2.0 e-reader contain such assistive technology (screen readers) that contain different languages and responded quickly when screen reader users select the language according to their need. Assistive technology (speech synthesizer, screen reader) contain one language for whole e-book document including reference link, label etc. Some assistive technology is skipping the reference link. The result is the reference link, label is in different language than the e-book language. For instance, e-book language is in Spanish then reference label is in English language. If screen reader users select the Urdu language and doesn't understand the English language, then it creates problem to them. Hence, language speech synthesizer must contain completely one language if it is English then speech synthesizer read whole book content in English including reference link.

The main purpose to define lang attribute in the document is to help the users who use screen reader. Users can select different language according to their need (Allan, Lowney, Patch, & Spellman, 2015, Success criterion 1.6.4).

Hence, lang attribute increase the readability of assistive technology and help users who use the screen reader to identify the language of the page.

#### 5.1.4 Problem 4: improper formatting

According to the WCAG 2.0 success criteria, some sentences, words sometimes describe the whole story in the e-book document. These are the special text. For instance, if there is a narrative sentence in the document then people can read it by its inverted commas expressions, but it creates problem for the blind people and screen reader users because they cannot see these special expressions provided by the author in the e-book document. Hence, these special words, paragraphs must be written in the “em” and “strong” element tag for the screen reader. Screen reader reads the text that are enclosed with a proper semantics markup for the screen reader users. Formatting also play an important role in term of accessibility of e-books. In an accessible e-book document must be format according to WCAG 2.0 accessibility guidelines and technique. All the tags associated with the special elements or formatting must be used in the source file so that e-reader assistive technology can read it aloud for the blind people and other screen reader users (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.3.1,4.1.1,4.1.2).

According to UAAG 2.0 user agent support notes assistive technology must support semantic elements so that people with no vision identified the special content in the text. It should be provided in any e-reader assistive technology to make emphasize on special content in the text. The sentence in the parenthesis, block statement, quotation etc. must be readable by assistive technology for the blind people and other screen reader users. (Allan, Lowney, Patch, & Spellman, 2015, Success criterion 1.6.3).

#### 5.1.5 Problem 5: List is not created properly

This is again about an accessible formatting in the document for the people. According to the WCAG 2.0 accessibility guidelines and techniques, a list element tag is used to create an accessible link in the document. If list is created in a proper tag, then list is accessible and readable

by the screen reader to the people who used screen reader and blind people as well. Hence, ol and ul element tag is used to create a list to make the document accessible.

The formatting should be accessible, and every list must be format and have proper tags to design the list. Screen reader users easily understand the list if it is in proper list format. (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.3.1).

#### 5.1.6 Problem 6: visual elements are not accessible

This is for all the visual data that are used in the e-book document. According to WCAG 2.0, all the visual data must be described by the additional text (alternative text) for the blind people and other screen reader users. Visual elements are in the form of images, shapes, diagrams, formulas, mathematical expressions and other non-text element. If additional text or alternative text are not provided by the author in the e-book document, then it is meaningless to the screen reader users (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.1).

#### 5.1.7 Problem 7: usage of blocks creates navigation problem

Use links in the e-book to navigate the e-book content easily. Links increased the readability and usability of the document (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 2.4.1).

### 5.2 Result discussion of manual testing

#### 5.2.1 Test case 1

According to WCAG 2.0 accessibility guidelines and technique, the document structure should be formatted according to accessibility guidelines and techniques. In case, publisher is responsible to check the document according to accessibility guidelines before publishing the electronic document whether it is e-book or some other electronic document. The font color, style, size, foreground color, background color, line spacing, paragraph spacing, sentence length, how many

words in one sentence or in one line of the paragraph should be according to WCAG 2.0 accessibility guideline and technique. Hence, there must be some option or button inside the e-book to adjust the formatting setting according to user need. (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.4.8).

According to UAAG 2.0 user agent implements the user-selected text configuration setting and through this option user can set the text size, style, line spacing, font size, font style, paragraph, alignment (left, right, centered), justification to make the e-book document more accessible (Allan, Lowney, Patch, & Spellman, 2015, Guideline 1.4).

According to UAAG 2.0 provide many assistive technologies to adjust the viewport according to the user need. E-reader must have assistive technology that provide a better viewport to its readers and readers choose the viewport according to their need. For instance, reader can (highlight, resize, select different options of viewport, customize the viewport and many other features of viewport) choose according to their need (Allan, Lowney, Patch, & Spellman, 2015, Guideline 1.8).

Hence, the retailer (who is responsible to publish the e-book in the e-shop) make sure that e-book structure according to WCAG 2.0 and the e-reader has different viewport options provided by the developer to make the e-book accessible. If the retailer checks every accessible feature before making it available on e-shop, then accessibility can be achieved.

### 5.2.2 Test case 2

According to WCAG 2.0 guidelines and techniques, screen readers usually skip the abbreviation as well as skip the rules of language. For instance, doctor abbreviation is “dr” and screen reader reads d and r instead of doctor that creates problem to understand the meaning of actual word and sentence. Moreover, WCAG abbreviation is Web Content Accessibility Guidelines so screen reader treated WCAG as WCAG to read individual alphabets rather to speak its full form. Hence,

to overcome this accessibility issue in e-book documents is whenever the abbreviation came first time in the text provide its full form clearly so that the blind people don't get confused next time when the same abbreviation came in the text. Other option is to provide some dictionary option in the index or glossary part of the e-book to check the proper abbreviation. Through user Agent, provide full form of abbreviation in the text to achieve the accessibility (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 3.1.4).

According to UAAG 2.0 there are many different types of alternative text and to avoid them in accessibilities in the web user agent enable some extra expanded information of them. Like WCAG is the abbreviation of Web Content Accessibility Guidelines and Techniques then user agent provides its expanded form in the element tag `<abbr></abbr>` (Allan, Lowney, Patch, & Spellman, 2015).

### 5.2.3 Test case 3

According to WCAG 2.0 accessibility guidelines and technique the people who are blind, low vision and people who have some reading disabilities have problem especially when the meaning of word depends on pronunciation. These words depend on the whole sentence. Sometime the words are so complex and difficult to understand its meaning after reading the whole sentence. So, WCAG 2.0 guidelines help the blind people and the people who have reading problems provides some techniques to overcome this accessibility issue in e-books. WCAG 2.0 guidelines provides some suggestion to overcome the issue by sound file that contain proper description along different meaning of same words. For instance, whenever such words came in the text there should be a sound file link that contain proper pronunciation of those words with different meaning. Moreover, in glossary section link those words and give explanation to the glossary part. Provide some additional information of the words in the text part and clearly express the two-different meaning of the same word (Caldwell, Cooper, Reid, & Vanderheiden, 2008).

#### 5.2.4 Test case 4

To determine the punctuation marks in the document and reader can feel the punctuation expressions in the e-book, then UAAG 2.0 user agent provide the accessibility feature of speech synthesis. Through speech synthesis assistive technology, the reader can feel the excitement, emphasized sentences (enclosed in inverted coma's), question sentences, and other quotation sentences. Through speech synthesis assistive technology, reader can adjust the volume rate (slow, fast, medium) according to their need. Moreover, by selecting the option to speech directly or in a pause (reading with expressions) to active or inactive the punctuation expressions via speech synthesis (Allan, Lowney, Patch, & Spellman, 2015, Guidelines 1.6).

#### 5.2.5 Test case 5

Navigation is a very important part while reading e-book through screen reader. A good and accessible layout (designed according to accessibility guidelines) help the screen reader users to navigate the e-book content easily. WCAG 2.0 guidelines helps the author to design the accessible layout in e-book. Title, order, headings, sub headings, links, hyperlinks, label, formatting and other content design depend on navigation. Moreover, to do a better navigation or an accessible navigation then all must be designed according to accessible guidelines (Caldwell, Cooper, Reid, & Vanderheiden, 2008, Guideline 2.4).

WCAG 2.0 accessibility guidelines provides some suggestion about navigation that helps to write the content of e-book and to maximize the accessibility features. These guidelines provide following points to avoid inaccessibility. Add less links and hyperlink in the e-books because more links creates problem to navigate the e-book content and avoid making complex navigation structure. Add headings and create different types of heading and divide them into the section heading. Always add label and meaningful alternative text to every link and hyperlink to achieve the accessibility (Caldwell, Cooper, Reid, & Vanderheiden, 2008).

According to UAAG 2.0 navigation can be sequential. For instance, author can specify the navigation order, but the default order is sequential. Screen reader read the keyboard focus content and user can operate and navigate the content by pressing the keyboard keys backward and forward. User agent must have a wrapping option so that people who have a low vision and using magnification option can choose the wrapping option according to their need rather to lost while searching a specific element in the list. User agent aware the users about the wrapping option either it is turned off or on. Here, users also need to learn the navigation how to navigate and what are the navigation commands and how to adjust the user agent options according to their need etc. User agent also provide an option to direct navigation from a selected word in the text and content in the e-book. A user can navigate the content of the e-book where he/she wants to navigate (Allan, Lowney, Patch, & Spellman, 2015, Guideline 2.2, 2.3, Success criteria 2.2.4).

#### 5.2.6 Test case 6

According to WCAG 2.0 accessibility guideline and technique, if the technology doesn't provide some zoom option to its user then the user interface is designed and provides some functionalities and features of zoom option and bigger text option including images etc. in e-books so that user can facilitate over there. Before publishing the e-book, document author is responsible to check that there must be font resize option for people with low vision. In other words, e-book document must provide accessibility option of resizable text so that in case if assistive technology doesn't provide the magnification, font size option user can use e-book document accessibility features (Caldwell, Cooper, Reid, & Vanderheiden, 2008).

According to UAAG 2.0 e-reader, web sites and a digital document who have graphical content in it always provide zoom option to the users. This feature is for everyone. Anyone can adjust the zoom option according to their need. When user choose the font large or font size increase option then it only deals with the font and skip the graphical content. Graphical content are images, diagrams, shapes, charts, tables and other non-text data. Hence, zoom option provide a bigger

picture for both text and graphics. When user select, e-book zoom option designed by author then user agent disabled his zoom option in style sheet css. On the other hand, when user select user agent zoom assistive technology then author zoom feature is disabled automatically in the stylesheet. Zoom option helps the people with low vision to make or view a bigger picture for both text and graphics. Moreover, zoom in option can be used to view the structure of the document in one screen. User agent provide 500 % to zoom in and 10 % to zoom out (Allan, Lowney, Patch, & Spellman, 2015, Guideline 1.7).

#### 5.2.7 Test case 7

According to the WCAG 2.0 accessibility guidelines and technique the color contrast ratio will be 4,5:1 except the logo image, attractive image, and large text. Sometimes information is displayed in the form of color. For instance, sometimes output or result of wrong entered input are in the form of color then this make difficulty to sighted people, people with low vision and those who cannot differentiate with colors like old people. Hence, to make it accessible provide such mechanism that help everyone or to enhance the accessibility by using the colors. Visual presentation of document effects the reading of people with low vision. Foreground and background color play a vital role in reading for those people who have vision problems. The accessibility guidelines help the developer to make the accessible content and provide a feature to the users to adjust the foreground and background color according to their need. The font size can be increased up to 200% without the assistive technology (Caldwell, Cooper, Reid, & Vanderheiden, 2008, Guideline 1.4).

#### 5.2.8 Test case 8

According to the WCAG 2.0 accessibility guidelines and techniques, all the non-text content must provide alternative text description that is equivalent to non-text content. The text description must be meaningful and describe the non-textual content. Non-text content can be image, decorated image, diagram, charts, shape, graphs, table, pre-recorded video file etc. Screen



reader assistive technology reads the alternative text aloud to the blind people and other screen reader users. For instance, if the e-book contains images and text in the form of image then alternative text should describe the text in the image and image. Moreover, if there is pie chart in the book then alternative text explain its percentage ratio of pie chart to blind people. If prerecorded video found in the e-book, then provide audio equivalent to prerecorded video to blind people or screen reader users. Moreover, WCAG 2.0 accessibility guidelines say that if non-text element is only for very decoration then it can be ignored by the assistive technology. (Caldwell, Cooper, Reid, & Vanderheiden, 2008, Guideline 1.1).

Alternative text provided by the author is read by the assistive technology. Whenever content found in the e-book or digital document have alternative text or non-text content then the user agent authoring tool declare that alternative text is going to be read against the non-text content and screen reader reads it aloud. Moreover, if author forget to provide alternative text against the non-text content then user agent should provide some metadata “no alternative text found “and read aloud by the screen reader (Allan, Lowney, Patch, & Spellman, 2015, Guideline 1.1,1.3).

#### 5.2.9 Test case 9

Provide graphs, diagram enough information to the alternative text to make them accessible. Screen reader users listen to the alternative text through screen reader for the accessibility. The non-text content according to WCAG 2.0 and UAAG 2.0 was also briefly discussed in test case 8.

#### 5.2.10 Test case 10

Sequence play a very important role to understand the e-book content as well as to navigate the content through assistive technology. E-book should contain a proper reading sequence e.g. chapters, headings, sub headings, paragraph, table data in proper order. Correct reading order is easily navigable by screen reader. Guideline follow one correct order at one time. There may be more than one reading order, but linear or sequential reading order is good reading order to

obtained accessibility in e-books (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.3.2).

#### 5.2.11 Test case 11

According to the WCAG 2.0 accessibility guidelines, if the document contain table then it must be fully formatted. Table must contain a proper header and data cell; column and rows must be formatted according to accessibility guidelines and techniques. In the table, table caption, table summary, row header and column play important role and through them screen reader determine the table and read it. If the table is without the header and data cell, then the assistive technology cannot treat the table as a table. Table without the header and data cells treated as a simple text by the screen reader. Table caption is the identifier of the table. In addition, the alternative text or summary of the table must be provided that contain meaningful information and describe what is table about and what type of information the table contain e.g. comparison of two things, description of something, images and other data. If there are any images in the table then it must be in line with the table text and with a proper meaningful alternative text and fully formatted (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.3.1).

#### 5.2.12 Test case 12

To create an accessible document WCAG 2.0 guidelines it is prohibited to add images with text in the document. Accessibility guidelines says that write text to convey the message rather than image of text. Moreover, logo image and decorated image and large scale-text contained text and have 4.5:1 contrast ratio. Hence avoid visual presentation to create an accessible document (Caldwell, Cooper, Reid, & Vanderheiden, 2008, success criteria 1.4.5, 1.4.9).

### 5.3 Recommended accessible point for the e-book document

Following are the possible accessibility points that must be in an accessible e-book before making it available on e-shop. Following accessible points help the author to make an accessible e-book document for the blind people and people with low vision. WCAG 2.0 web content accessibility guidelines are for the website, but with the help of WCAG 2.0 accessibility guidelines and techniques I am able to recommend possible accessibility points for the e-books document and e-reader after testing the different e-books. These points are not all the accessibility points in e-book document but some of them that is important for low vision and blind people is discussed below.

- Provide alternative text to visual data like images, shapes, diagrams, graphs, table, pictures and other. Alternative text should be meaningful and easily understand by blind people and other screen reader users.
- Provide a good layout and structure of e-book. For instance, e-book content is designed in a manner that is easily navigate through screen reader. use proper links, label, heading, sub headings, table is accessible by its header row. If there is some image in the table then design the table content in such manners that is easily navigable and provide alternative text description to visual data in table. If there are any images in e-book containing text, then provide a proper description of text in image through alternative text. Blind people and other screen reader users understand the text in image easily. Visual data must be in line with the text. For example, provide captions of every visual data in the e-book.
- Provide an accessible table of contents with a sequential layout. For instance, book chapters with their appropriate page number of e-book. Screen reader navigate the e-book content (table of content) easily
- Text should have organized in such manners that is easily visible to low vision people. Provide font size, font background and foreground color, font style, zoom in, zoom out option in e-book as well for the low vision people. So, low vision people can adjust the setting according to their need.

- If there is any video data, then provide appropriate description to video in form of audio to the blind people and screen reader users. Audio file automatically enable whenever screen reader found video in e-book. Audio of video provide the same information that are in video data to blind people and other screen reader users.
- Provide a back, forward button, button or link of table of content page in each page of the e-book so that users can easily access the back page of the e-book. By pressing the back button previous page of e-book is appearing. By pressing the forward button next page of e-book is appearing. Similarly, by pressing the table of content button or link pop up menu of table of content is appeared and user select the required page of his/her desire. E-reader accessible tools provide the option of table of content, but it should also be embedded in e-book so that user can easily visit the chapters of e-book through the accessible buttons (back, forward, table of contents).
- Avoid putting decorative images in e-book because it is ignored by assistive technology. To make the e-book content accessible put those content that is easily accessible by assistive technology, accessible tools. So, lot of decorative images create inaccessibility so avoid decorated pictures in e-books.
- Provide a proper list in e-book explicitly for the abbreviation words and homophones words with their meanings to the users including users with disability. So that users are not confused and misunderstand the words in the e-book text. There can be two ways of providing the abbreviations and homophones in e-book to achieve the accessibility. First, provide a full abbreviation list and homophones words meaning after the table of contents and before beginning the e-book. Second, whenever abbreviation and homophones words came in the text then screen reader read the abbreviation and homophones words meaning automatically. Assistive technology contains the abbreviation full list and homophones meaning in it.

- Reading order of e-book should be good and easily navigable by the screen reader.

The most important part of e-book accessibility is retailer confirmed that e-book is designed according to accessibility guidelines and technique before making it available to e-shop. On the other hand, e-readers provide accessible tools and assistive technology according to e-book contents.

#### 5.4 Limitations of the research

The master thesis “e-book accessibility” test the different e-books and e-readers (assistive technology and accessible tools) for the blind people and people with low vision. Different testing technique was conducted to fulfill the research goal. The limitation of the “e-book accessibility” research is e-books testing with the real users was not conducted. However, user testing plan (questionnaires, interview questions) was discussed in the research, but actual user testing (with the real users) was not conducted in the research and this is the limitation of the research. Moreover, only blind people and people with low vision was discussed in the research. Possible e-book accessibility problems tested with only for the blind people and people with low vision. People with other disability was not discussed in the research and this is also the limitation of the research.

#### 5.5 Future work

The future work of e-book accessibility research will be to conduct the user testing for the blind people and people with low vision. The aim of user testing will be to find out more accessibility problems in e-books and e-readers. What real users wants in term of e-book accessibility will also be noted? Are they satisfied with existing e-book document, assistive technology and accessible tools? What type of accessibility problems they are facing while reading e-books? After conducting the user testing, an accessible e-book point will be recommended and suggested, that help the retailer, author and programmer to develop an assistive technology, accessible tools and

design an accessible e-book document for the people including people with disabilities. Moreover, future work will also be focused for those people who have other disabilities like people with dyslexia, learning disabilities and many other disabilities.

## 6. Conclusion

E-book accessibility research was mainly about the accessibility problems in e-books for the blind people and people with low vision. Research had two parts one was to identify the possible accessibility problems and accessibility features in e-books for the blind people and low vision people. Second part was how accessibility improved in e-books with the help of WCAG 2.0 and e-reader with the help of UAAG 2.0.

Different journal articles, websites, books, conference papers were read to find out the e-book accessibility problems for the people with low vision and blind people. Background study conducted to find out the accessibility barriers and accessibility features for the blind people and people with low vision. Moreover, different e-books were tested to find out the accessibility problems both in e-book document and in e-readers by using testing techniques (manual and automated). The results of testing were the accessibility problems in e-books and lack of assistive features in e-readers. Background study and testing different e-books results are the answer of research question one that is listed below.

What are the specific problems and characteristics of e-book document and e-reader in term of accessibility for blind and people with low vision?

Second part of e-book accessibility research was how WCAG 2.0 and UAAG 2.0 improves the e-

book accessibility for the blind people and people with low vision. Hence, the answer of research question one is further discussed according to accessibility guidelines and techniques. In other words, the accessibility problems in e-books and lack of assistive technology in e-readers further discussed according to WCAG 2.0 and UAAG 2.0. Guidelines, success criteria of each accessibility problems identified in research question one is briefly discussed to answer the research question two that is listed below.

How can the WCAG 2.0 and UAAG 2.0 accessibility guidelines improve the accessibility of e-books and e-readers?

After the answers of both research questions, accessibility points were recommended to the publisher and author for the e-book document for the blind people and people with low vision by the E-book accessibility researcher (Hina Shahzad). These accessibility points are for the e-book document with the help of WCAG 2.0 accessibility guidelines and techniques.

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## **Appendix**

A result file from the EPub automated testing. E-book treasure island





## EPUB Validator (beta)

### Results

**Detected version:** EPUB 2.0.1

**Results:** The following problems were found in *treasure island.epub*:

| Type  | File  | Line | Position | Message  |
|-------|---|------|----------|--|
| ERROR | OEBPS/@public/vhost@g@gutenberg/html/files@120@120-h@120-h-0.htm.html | 7    | 136      | Error while parsing file 'attribute "tag" not allowed here; expected attribute "charset", "class", "dir", "hreflang", "id", "lang", "media", "rev", "style", "title", "type" or "xml:lang"'. |
| ERROR | OEBPS/@public/vhost@g@gutenberg/html/files@120@120-h@120-h-0.htm.html | 17   | 57       | Error while parsing file 'attribute "xml:space" not  |