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Development and Evaluation of Crowdsourcing Application Prototype in the Context of Universal Design

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Abstract

During the recent years, World Wide Web becomes the main source of information for every sector like, academic, medical, social and almost everywhere and for everybody. Usable system improves user performance and satisfaction where it shares some key goals with accessibility and universal design. So, usability evaluation is important part in overall user interface design. For designing the usable web, different principles and guidelines are available and recommended for designers from specific to general. This study focused towards the re design of Distributed Proofreader user interface with the aim of maximizing usability and universal design so, literature review is conducted, Prototypes are designed and developed and developed prototypes are evaluated through the users and results has been documented. Moreover, research questions have been answered by evaluating the prototypes and results are discussed, after the evaluation of the prototypes users preferred newly proposed distributed proofreader user interface, which is more universally designed and usable.

Keywords: accessibility, usability, universal design, Distributed Proofreader

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1. Introduction

Internet has reached almost every part of the world, which connects all people together. World Wide Web consist thousands of web sites to provide services and information in different areas like education, business, medical and so on. But one aspect is that whether these services are accessible for all the potential users, because universal design maintains the usability by providing the satisfaction and effectiveness to the large number of user by use of system. Moreover, usability is essential to improve user interface of the system like if user get lost in the web page, then potential users leave to visit which would be big loss for service provider or companies to sustain in the competitive market or convey information through their channels so, universal design address those issues by making system and services accessible for diverse users. Usability and universal design is wider term but particularly in this study is about on web user interface. Moreover, it is important to insure that all information communication technology (ICT) products and services are accessible and usable by maximum number of people regardless of their abilities so, universal design make this happen (Rosenkvist, Svensson, & Wretstrand, 2014).

Physical books have been digitized in eBooks through optical character recognition (OCR) with different algorithms. In one study Coyle (2006), described how mass digitization takes place, which means large libraries has been converting in to electronic form without selecting individual materials by using todays advanced technology like, the photography process that create digital image and OCR which process the image, but proofreading is important to make the eBook error free because accuracy of OCR technology is not same in all situations, like, performance decreases when unclear text is appear in physical books. In this context, proofreading is important to avoid those errors but this process is time consuming and expensive when this task is appointed to limited number of peoples especially when books are too lengthy. So, the concept of crowdsourcing is introduced in proofreading. In one study, G. B. Newby and Franks (2003) described, distributed proofreader (DP), which allow large number of people individually working on Internet to contribute to proofreading electronic books. More specifically distributed proofreading portal is chosen for this study, which allows many peoples working individually on Internet to contribute the proofreading eBooks.

Proofreading is accomplished using web interface provided on portal where proofreader compare the OCR output and make necessary changes in editable format. Usability is about efficiency, effectiveness and satisfaction so, usable website or usable user interface is very important to provide satisfaction to users and effective on use. Numerous amount of work has been done on user interface design and its guidelines. L, Sajedi, Mahdavi, and Nejad (2008) introduced fundamental user interface design guidelines that designers consider to improve usability and universal design. Similarly, Story (1998) discussed principles of universal design, can be implemented on user interface design. More specifically, when cognitive load theory (CLT) implemented in human computer interaction (HCI), system will be more usable and user friendly like, Nielsen (1996) described the heuristic "Recognition rather than recall" where user should not have to remember information from one part of the dialogue to another. Because, CLT based upon the notion of limited working memory capacity and vast long-term capacity (Hollender, Hofmann, Deneke, & Schmitz, 2010). So, limited working memory cannot hold large information for a long time and system becomes less usable and less inclusive, if these principles are implemented in design process the system becomes more usable and universal design. So, universal design of the Distributed Proofreader web interface plays important role to accomplish the task effectively and gives more satisfaction to users. The aim of this study is to evaluate usability of existing DP web user interface from universal design perspective and, newly proposed prototype is developed and evaluated through experiment with an aim to develop universal design user interface.

1.1 Problem Statement

How to build good usability and universally designed web site is still a problem (Hu, Chang, & Menezes, 2006). Universal design enables effort can contribute toward better-designed system, product and services (Mustaquim & Nyström, 2013), where universal design principles can be used as a foundation to design or redesign the system and services which improve the usability like, it is believed that less cognitive load a learner has to carry, the easier learning should be (Chalmers, 2003) and universal design of system be achieved by integrating cognitive load theory in user interface.

Various usability, and universal design guidelines have been developed, ranging from high-level usability goals to specific design principles (Chalmers, 2003). Recurring usability goal is to reduce memory load for users (Hollender et al., 2010), for reducing memory load consist of having users focus on recognition rather than on recall like, preventing users from having to remember information from one screen to another by keeping display simple and clear rather than memorize, because memorization decrease usability of the system and becomes less inclusive.

Users have trouble to remembering information presented on computer display because, the limitation of human working memory is well known and widely accepted (Chalmers, 2003). Sweller, van Merrienboer, and Paas (1998), Working memory is capable of holding only about seven items or chunk of information at a time. Similarly, universal design principles, usability guidelines and rules have also mentioned, through the guidelines cognitive load can be reduced and system can be usable as a result. Hollender et al. (2010) mentioned remembering information from one screen and using same information in another screen decrease user performance and reduce overall usability of the system.

1.2 Research question

Maximizing the performance is the main aim of the proofreader portal with high quality result and make accessible for large number of users, which is possible through universal design. This study specially addresses the following research questions. Below are the research question related to the problem statement.

RQ 1: Does the universal design user interface improve the performance and productivity while performing the task?

This research question is divided in to following questions for better understanding.

RQ 2: Does cognitive load theory based design makes easier and productive user interface?

RQ 3: Does reducing memory load on DP user interface becomes more inclusive design and improve the usability?

After conducting the literature survey, it is noticed that existing DP user interface can be re designed and developed for universal design to maximize the usability and make usable for different kinds of abilities where universal design principles, usability principles and guidelines can be implemented on new design for better usability and inclusive design. From these research questions a hypothesis is formed to conduct the experiment.

H0: In user interface, there is no significant effect of working memory load on user performance.

H1: In user interface, there is a significant effect of working memory load on user performance.

2. Literature review

2.1 Crowdsourcing

Technology is rapidly getting more advanced and spreading all over the globe. In recent years lots of work has been done by the researchers in different fields to replace the traditional way of doing with new techniques like, crowdsourcing is one that reach among the peoples around the globe and try to solve or generate new ideas by analyzing the output from large community with similar interest.

The idea of crowdsourcing is not new, writer ("crowdsourcing is not new-The history of crowdsourcing(1714 to 2010),") said that in1714 the British Government had problems with longitude problem and they offered money to peoples to solve that problem which is one example of crowdsourcing, similarly in 1936 Toyota company announce for Toyota logo contest and got logo from thousands of entries from peoples and one got selected. Moreover, there are so many companies and firms used this technique to get suggestion from the audiences. In 2006 the term crowdsourcing was introduced by Jeff Howe in magazine and now many crowdsourcing applications and websites available which create positive impact on companies to make the decisions or even individuals getting benefit by obtaining feedback of their queries by experts.

Crowdsourcing is defined as the act of outsourcing tasks assigned externally to people to heterogeneous mass of potential actors, that happens by means of involving peoples via internet (Hammon & Hippner, 2012). Application of crowdsourcing can be divided in various categories like, micro working or micro tasking. In this type of crowdsourcing, organization assigns small pieces of tasks to many workers (Chiu, Liang, & Turban, 2014). Similarly, crowdsourcing is related to other concepts like, co-creation, collective intelligence, user innovation and so on. Different health crowdsourcing websites are exists and have been collecting data related to their interest where patients report their symptoms (Armstrong, Harskamp, Cheeney, Wu, & Schupp, 2012). Crowdsourcing is popular in different sectors, because crowd have crucial role in human computation, not only provide computational power also accomplish the task where machine barely can do with efficiency.

The crowdsourcing has been used in document digitization to correct the noisy optical

recognition (OCR) text. In recent years millions of books, magazines has been digitized in eBooks or electronic forms to provide full-text search capabilities where these documents are converted by the means of OCR and the accuracy is depends on the quality of documents, type of text used, quality of paper and so on, so text correction can be done by crowdsourcing (Hlberger et al., 2014). There are some OCR projects like Australian Newspapers Digitization Program, Distributed Proofreader, Transcribe Bentham (Andro, 2014), where people involve to correct the text.

Crowdsourcing has emerged in recent years with tremendous potential for today's digitally connected, diverse and distributed workforce where it outsource tasks to large number of people on the web by offering the opportunities to accomplishing the task from large participants more accurately and at lower cost than traditional approach. Alonso and Lease (2011) introduced the challenges and opportunities of crowdsourcing and they discussed how to achieve efficient, inexpensive and accurate result with crowdsourcing. Like Wikipedia which is the example of crowdsourcing has large encyclopedia on the web where Meta data available and can be analyzed to get the better understanding of the content by combining knowledge from the large number of users and emphasis the group knowledge to maintain accuracy.au

Aldhahri, Shandilya, and Shiva (2015) Studied on effective crowdsourcing recommendation system, in crowdsourcing system there are three-stakeholder worker, requester and a service provider. The requester posts the task to the crowd, worker work on it and finally service provider work is to match workers with tasks and found that less experience worker who have more time and could increase the solution efficiency.

Distributed proofreader (DP) is a crowd sourced website whose volunteers convert book in to the electronic format so; concept of crowdsourcing is implemented on document digitization to create electronic version of books ("Distributed Proofreaders,"). Moreover, G. B. Newby and Franks (2003) said, DP is a way for people to get involved with producing a project Gutenberg eBook, which provides a web based platform to conversion of public domain books in eBooks by using the concept of crowdsourcing by dividing the work load in to small scales and distribute the document to many registered volunteers where they can work at the same time to complete the given task.

2.2 Digitization of document

Converting physical documents of any kinds, books and magazines to their digital form is very popular now days which improve productivity and efficiency similarly, helps to manage documents in archives in a organized structure and more important its continuous availability on the web which is difficult in physical format.

The conversion of large collection of documents from paper to digital format is suitable for electronic archival is a complex multi-phase process (Yacoub et al., 2005). Where they described a life cycle of documents in four phases.

1. Scanning: in this step paper document is converted into raster images like, high-speed scanner can be useful for scanning.
2. Automatic Document Understanding System: Document-processing system is used to analyze the scanned image and recognize text.
3. Computer assisted manual correction: errors on text are corrected in this phase by comparing the original image.
4. Deployment: information is stored in this phase.

In one study, Perry (2009) described, significant effort is being made by a number of companies and universities such as Microsoft and Google have scanned large number of books and digitized. Numbers of libraries agreed to help those companies to provide literatures and books and they have been working on it. Like, in October 2004, Google announces its partnership with several large publishers (Perry, 2009) for digitization named Google Print and later changed to Google Book Search to digitize millions books from libraries from USA and UK. Similarly, Perry (2009) described, in 2005, Yahoo, the Internet archive and many research libraries and libraries like University of California and University of Toronto, announced a project called Open Content Alliance to digitize the books in public domain similarly, Million Book Project was the first mass digitization project founded by the different countries like, US National Science Foundation, India and China and this project has digitize over 1.5 million volumes from different libraries around the globe like, China, India, Egypt. Similarly, many more projects working for digitization like, project MUSE provide hundred percent free online access of some humanities and social sciences journals (Dougherty, 2010), and on March 2006, the Australian reported that the European Commission plans to make at least six million

books, documents and other cultural works available by 2010 (Hahn, 2008). Which indicates that numerous amount of work has done on digitization to make available on web or in electronic format.

Maintaining accuracy in eBook is one challenge for those projects, because of its multi stage process to accomplish. Gregory B Newby (2003) describes general steps for digitization of Project Gutenberg eBooks are to:

1. Identify a printed copy of a book from internet
2. Access whether this item is in public domain
3. Scan the book
4. Perform Optical Character Recognition (OCR) on the book
5. Proofread the OCR output
6. Conform the formatting meets guidelines and submit the eBook for distribution

In one study Coyle (2006) described, how mass digitization converting whole libraries in digital form without selection of individual materials. For doing these tasks companies like Google and Microsoft have been using different scanning techniques like photographing and using scanners and subjecting those images to optical character recognition (OCR) software to produce editable text. There are two main parts of this technology one is photography process which create digital image of the content and another one is OCR that convert image text to text on the page (Coyle, 2006).These improvements shows less human effort are needed in the process and performance of scanner and OCR is improved.

Project Gutenberg emerged on digitization and digitized thousands of books, which are available in digital format (Coyle, 2006). This project has been involving volunteers to participate in digitization process. Scanning and digitizing the documents was very difficult before but improvement on scanning technologies and availability of software makes easier to perform these tasks now days. Like, highly advanced scanners are available in libraries to scan large amount of books (Rapp, 2011).

Numerous amount of work has been done in the digitization to improve the efficiency and performance of digitization technology (Ding, Wen, Peng, & Liu, 2004). The author described document digitization technology and its applications for creating digital

libraries in china where main focus on performance and efficiency of TH-OCR system and found significant role in digital libraries in China where new OCR technology are presented for character recognition. OCR technology has improved over time and improving its computational time. Coyle (2006) described OCR language capabilities, which is available in so many languages like OCR software Abbyy can convert on 177 languages but the accuracy of software depends on the quality of the text. Similarly, writer Ding et al. (2004) studied user experience among different devices like Amazons Kindle, Apple iBook, and Barns and Nobles Nook and tried to investigate the issue on readability, comprehensibility, and satisfaction by measuring two factors which is: line spacing and numbers of columns and investigated low number of columns increase the readability by experimenting with the participants.

Digitization process starts with document selection process, once document is selected than scanned with devices and performed OCR. OCR parameters should be taken into consideration such as language models; dictionary and font of the text in order to maximized the accuracy of OCR process. But, the accuracy of OCR cannot measure 100 percent and sometimes quality of OCR could not be satisfactory because its performance depends on quality of text, paper, and color. However, researchers have been doing work to improve the performance of OCR by introducing different algorithms. So, while in the digitization process, error minimization or accuracy maximization could be the challenge particularly in mass-digitization. Authors Zakariah, Janom, and Arshad (2015) proposed pattern recognition approach to correcting errors in OCR generated text. Commercial vendors claims the OCR is very accurate but reality is far different from that.

Many old books and other documents have variety of different problems and number of different processing steps required before OCR can run those documents effectively (Feng & Manmatha, 2006), such problem include noise, variable ink, marking by users, different text styles and so on which, decrease OCR performance. To obtain highest possible recognition accuracy, many processing steps carried out before applying OCR like, image rectification, cleanup, and de blurring (Feng & Manmatha, 2006). Which shows that error rate can be minimized in OCR out but still OCR is not 100 percent accurate. There are some OCR projects like Australian Newspapers Digitization

Program, Distributed Proofreader, Transcribe Bentham (Andro, 2014), where people involve to correct OCR output.

G. B. Newby and Franks (2003) described, before submitting the eBook to posting team, document should be proofread to avoid the mistakes and errors. Now days different software is available that can be helpful for this but that checker cannot catch all the mistakes. Proofreading is not difficult when document is short but it becomes difficult for eBook because of its size, single worker takes months to finish proofreading of single book (G. B. Newby & Franks, 2003). Project like; Gutenberg adapted the concept of distributed proofreading to support the development of e-text by participating many people to work together to perform drafts of e-books to reduce errors. According to G. B. Newby and Franks (2003) Distributed proofreading is an effort to support the project Gutenberg where basic concept is software allows several proofreaders to be working on the same book at the same time which speed up the proofreading process. When all the pages in the books have been proofread, combined all the pages together in one file and book are submitted to the project Gutenberg archive. During the proofreading, volunteers are presented with scanned page images and correct OCR text in single webpage. Single web interface is used for proofreading.

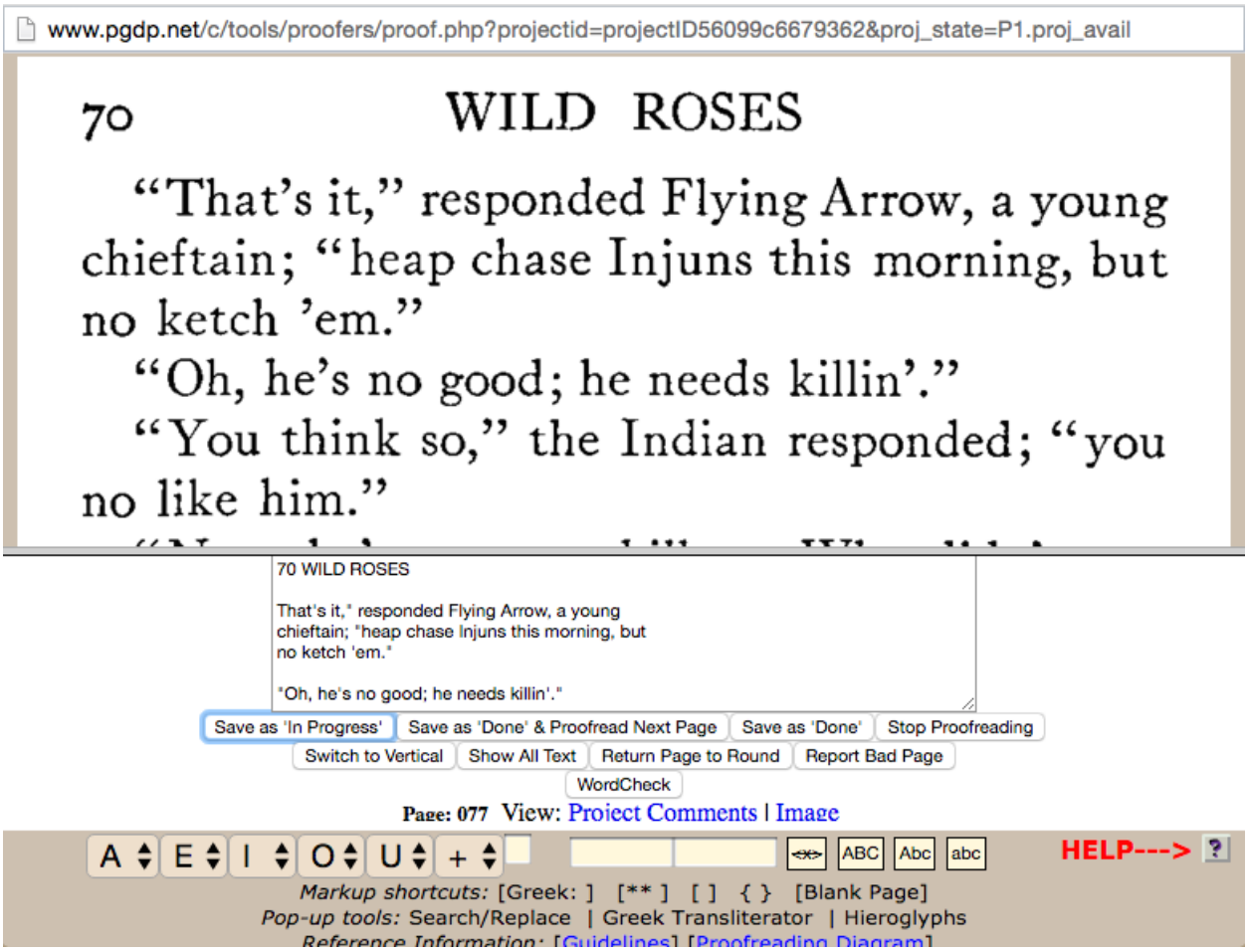

Figure 2.1: proofreader interface

Proofreader interface for project Gutenberg is appeared in figure 1 with all the available functionalities where scanned image of original text is on one screen and editable section is on other similarly, other functionalities can be used are appeared in buttons and dropdown has been used to customize the interface. Looking at image and correcting in another simultaneously is not easy task when dealing with long pages or unclear texts. So, this could be the challenge for proofreader to maintain the performance and speedup to finish the task.

2.3 Cognitive load

Usability of the product can be improved by reducing the cognitive load for users. In one study Chandrasekera and Yoon (2015) described, cognitive load theory which was introduced by Sweller where he suggested that the design of the instruction should not overload the learner's mental capacity because the working memory of human brains has limited capability. Like, if the interface is complicated and complex navigation, high workload imposed on users and increase cognitive load and usability decrease. The study focused on the effect of user interface type on the cognitive load imposed by interface and found Tangible user interface has lower cognitive load compared to graphical user interface but the different was significant. So, eliminating unnecessary features in the user interface helps to minimize the users cognitive load. Similarly, Oviatt (2006) said cognitive load is a global term that refers to the mental resources a person has available for solving the problem at a given period of time.

Cognitive load theory distinguishes between three types of cognitive load that occurs in working memory while learning (Hollender et al., 2010). The first, intrinsic cognitive load is defined by intrinsic complexity of information that is to be learned. Like, learning vocabulary is an example of low element interactively, as each word can be learned independently. On the other hand, how to make the sentence from foreign language is high element interactively because it requires of different parts of information. The intrinsic load of task only be defined in relation to the learners level of expertise (Bannert, 2002).

The second type of cognitive load, extraneous cognitive load, caused by inappropriate presentation of the learning materials (Ayres & Gog, 2009). Like, integrate information from separate sources increases extraneous cognitive load, information should be maintained in working memory to integrate with the information from another source (Sweller, 2006). Third type of cognitive load, germane cognitive load results from active schema construction process.

Both cognitive load theory (CLT) and human computer interaction (HCI) has strong focus on reducing unnecessary cognitive load (Hollender et al., 2010).

Hollender et al. (2010) discussed design principles derived from CLT. In reducing possible extraneous cognitive load, they described some methods; worked example

effect, split-attention effects, the modality effect, and redundancy effect. According to worked example effect, novice users prefer to solve on worked example rather than with conventional problems (Sweller et al., 1998). In split-attention effect Hollender et al. (2010) said “multiple source of visual information should be presented in an integrated way if all information source are a prerequisite for understanding” if the sources are displayed in different format then information need to be integrated mentally which increase load on memory(Sweller, 2006). Modality effect occur when multiple source of information need for understanding. And the redundancy effect Hollender et al. (2010) said “presenting multiple source of information that simply reiterate the same information in a different form should be avoided when one information source is sufficient for understanding”

Some CLT design principles have been applied in software design like, split design principle and the redundancy principle. Split attention principle says, if different pieces of information are related to each other then, user should not have to remember information from one part of the dialogue to another (Nielsen, Adelson, Dumais, & Olson, 1994). Similarly, the usability heuristic “every extra unit of information in a dialogue competes with the relevant units of information” (Nielsen et al., 1994) would prevent information from being reiterated.

Researchers have integrated the CLT concepts and HCI approaches in certain extent. Oviatt et al. (2006) mentioned applied usability principle to maximize usability in order to decrease extraneous cognitive load. Similarly, Chalmers (2003) pointed cognitive load principles for decreasing extraneous cognitive load to increase the usability of the system.

Writers Errey, Ginns, and Pitts (2006) described cognitive load in detail and concluded how designers helped by cognitive psychology and cognitive load theory to make the interface user friendly and efficient, because cognitive load refers the amount of mental activity that working memory has at a time. Cognitive load theory has been working in different aspects of human computer interactions or more specifically in interface design. Feinberg et al. (2000) described, they applied cognitive load theory to design of web-based instruction and found unnecessary cognitive load inhibit learning in web-based instruction and also in graphical user interface and found unnecessary elements impose

extra burden in user's mind. This indicates that minimizing cognitive load is important to make the user interface simple and usable and maximized cognitive load in user interface cause complexity on users and affect their performance. Feinberg et al. (2000) discussed, Cognitive model of learning, which consist following components.

Sensory memory: sensor memory deals with incoming stimuli from our senses, including sights, sounds, smells, touch, taste.

Working memory: working memory is a short-term memory is divided in three parts and learning takes place.

Long-term memory: long-term memory is a knowledge that we hold in a permanently accessible way. All the knowledge and information we know is held in long-term memory.

In this study they developed instructional website and tested with the users one with two different ways one used graphical user interface which minimize extraneous cognition and another with dual modality to maximize working memory and found that, cognitive load theory provides baseline for design of effective instruction. Similarly, cognitive load theory is consistent with general web design principles and provides additional criteria for effective web-based instruction. Which indicates that cognitive load theory provides baselines for web design. Interface is main mechanism towards communication between user and system so, successful user interface design minimizes cognitive load, which improve user's performance and satisfaction to perform.

Reis et al. (2012) has conducted a study on reducing cognitive load and enhancing usability through graphical user interface where they designed interface and experiment done with students on reduced and complete interface and found that the interface hides advanced features helps novice user better than complete interface. This study indicates that cognitive load play important role to design user interface, which affects usability of the system. Researchers have done so many work on cognitive load and its importance on human computer interaction and found the similar agreement on minimizing cognitive load maximize usability which indicates that cognitive load play important role in effective interface design.

2.4 Usability Evaluation

Over the last few years' web has been increasingly means of providing services and information to the users. Usability is the degree of compatibility of system with the users -cognitive characteristic for communication, memory and problem solving (Chou & Hsiao, 2007). According to Lee and Kozar (2012),usability refers "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" So, usability and performance have becomes an integral component of web site development to give easy and smooth access the users. Wood et al. (2003) suggested multidimensional web evaluation approaches and mentioned web evaluation methods as following.

1. Usability testing: this technique feedback can be obtained from experts and users
2. User feedback: feedback can be obtained from real users of the website
3. Usage data: data can be collected from various ways like web log analysis
4. Web and Internet performance data: website technical performance be measured using metrics like data transfer rate.

Manzari and Trinidad-Christensen (2006) said, in the usability testing when experts visit website and review the website, which is sometime call heuristic evaluation, could be effective for web developers because, experts has good knowledge and their perspective on related field but, sometime experts may not be aware about actual phenomenon from the outsides like, government policies and budget. Similarly, Sonsteby and Dejonghe (2013) said, usability can be evaluated by lab testing where organization or research group invites users to participate on testing and perform series of tasks which gives opinion on the system that provide room to implementation, but the problem with this evaluation is small number of users may not represent all potential users. Another method is user feedback method where random users be selected from the website to participate and certain task given to them to complete (Fernandez, Insfran, & Abrahão, 2011). This method can effective because large number of users can be participated in short time period. Similarly, users feedback can be obtained from external user panel survey where other companies work for the website. Likewise, another method is focus group where people provide information about the system, which can be done through online survey. In another study, writer Friess (2015) studied

empirical analysis of persona-driven heuristic evaluation where they tried to answers asked in research question which is finding from the heuristic evaluation of website without the use of personas differ from the finding from use of persons and did not found any significant difference. Usability heuristic was purposed by Jakob Nielsen for user-interface design guidelines called “usability heuristic” (Nielsen, 1996).Usability heuristic is developed by Jakob Nielsen and Rolf Molich where they purposed principles to guide the website is basically usability inspection method later often have been using on User Centered Design because of its simplicity (Friess, 2015). Research has done to find validity and effectiveness of heuristic method compared to other techniques and most studies shows their preferred method.

Persona have been used as a design tool but some suggested that persons could be used as evaluation tool because persona keeps evaluator user-centered but heuristic evaluation sometime become rule focused and become less effective in some cases. So, persona driven heuristic evaluation could be the effective evaluation technique (Friess, 2015). Now days web becomes important source of information but many websites are still inaccessible for the users with disabilities so evaluation is important to make the web accessible for all specially, for disable people. Writer Al-Juboori, Na, and Ko (2011) discussed some automated tools that identified usability problems like web XM, Booby, Alexa. Usability evaluation can be applied during any phase of the web design and development like early stage of evaluation helps to reduce extra costs but evaluation at the end can helps for further changes.

Accessibility of the web is another emerging concern among researchers and developers to create the universal design. Particularly, the concept of universal design creates services and products for the large number of peoples particularly for disable users. So, while designing user interface it would be helpful for larger users when we think of disabilities, which makes the web universally designed. In another study author Brajnik, Trewin, and McCoy (2009) had tried to investigate validity and reliability of web accessibility guidelines through the empirical study by setting experiment with some users. Similarly, quality of accessibility evaluation methods are discussed and argue that in accessibility evaluation checkpoints there is either success of failure so it does not provide the effectiveness of the web what the user actually think about the web. So

they concluded that there are large differences in effectiveness for the different checkpoints and between the guidelines sets. Which indicates that more research can be done to conform those results whether there is validity problem on different checkpoints.

2.5 Universal design and usability

According to Burgstahler (2011) center for universal design at North Caroline State University , Universal design is defined, as “ the design of product and environment to be usable by all people, to the greatest extent possible, without the need for adaptation or specialize design” which means providing equal field to all the member of society. Similarly, British Standard institute: Cremers, Neerincx, and Jong (2013) defines inclusive design as “ The design of mainstream products and/or services that are accessible to, and usable by, as many people, as reasonably possible without the need for special adaptation or specialized design”. The term inclusive design, design for all, universal design has same meaning. Several terms has emerged in recent years like accessible design, universal design and usable design which have similar thought but some distinct way in design ("what is the difference between accessible, usable, and universal design," 2015). The study concludes that, if designer apply universal design principles, with special focus on people with disability and usability experts involve participants to check the usability of the product, more products be accessible and usable by everyone.

Henry et al. (2014) described, universal design is the process of creating product and services that are available for widest range of people and abilities in different situations, where accessibility refers to design, services and products for people with disabilities. So, when design is focused in accessibility then it would be beneficial for all sorts of users in different situations. The concept of universal design emphasis the fundamental design of the web, which has the potential to work for all peoples whatever their language, culture, hardware and software. The study emphasis that the focus of accessibility needs remains on people with disabilities and services and products need to be built with their preferences. ("World Wide Web Consortium Launches International Program Office for Web Accessibility Initiative," 1997) The power of the web is in its universality so, to achieve this goal, accessibility is key on universal design. From the

1990`s the universal design gains greater interest among designers and service providers in the field of information technology to make the design for all, where many research has been done to understand the different dimension of diversity. According to world health organization ("World report on disbilities,"), world report on disability, more than billion people with disabilities have poorer health conditions, low income, low education because of the lack of services available for them. This evidence indicates that large number of people in the world has different kinds of disabilities and they are away from mainstream so one challenge is to provide all the services and technology, which help to live better life and make the society better. ("Designing for Inclusion,") described inclusive design, design for all, digital inclusion, universal usability and similar efforts address issues for making the technology available to and available for people with their abilities, age, geographic location, education, language and etc. and described people with different label of disabilities and how they use the web. Similarly, Web Accessibility Initiative (WAI) guidelines are mentioned to make the web accessible. There is a growing worldwide recognition that users with disabilities have the equal rights and opportunities to access the information technology and available services, which is the legislation in many countries, and making the necessary steps to implement on reality. Such legislation has led to creation of standards, guidelines for accessibility. Guidelines and standards are available to make the web accessible. ("Web Content Accessibility Guidelines (WCAG) Overview,") described, web content accessibility guidelines are developed through World Wide Web consortium in cumulative effort of individuals and organizations around the world with the goal of creating standard single platform for all users around the world. Moreover, WCAG focus on how to make web accessible for disabilities by providing preferred web contents like, sound, image, and structure and basically this technique is for web developers, accessibility evaluation tool developers and others who intend to make the accessible web. Similarly, W3C has mentioned briefly on web accessibility to provide equal access and opportunities to the people with diverse abilities, which is accepted and mentioned in their constitution by different countries and organizations. Like, UN convention on the rights of persons with disabilities recognizes the rights of diverse users in different field such as web and human right. Accessibility on the web refers

providing options to access the information with their preferences like, alternative text for image can access blind users with the screen reader, similarly keyboard input be useful for users who cannot use mouse. So, accessible web is under the universal design, which can be accessible for large number of people regarding their abilities, language, culture, skills, and experience.

Considerable amount of work has been done in universal design. Story (1998) discussed, seven principles of Universal Design were developed in 1997 by working group with the purpose to guide the design of product, services, environment and communication, which are following.

1. “ Equitable Use: the design is useful for diverse abilities and make the design simple and appealing to all users. Similarly, design should provide same meaning to all users and provide privacy, security, should be equal to all the users.
2. Flexible in Use: the design accommodates multiple individual options to perform and preferences and multiple methods to use the system and services similarly facilitate the users accuracy and precision.
3. Simple and Intuitive Use: design of the system should be easy to understand regardless of users knowledge, skills, and experience. Which means try to avoid unnecessary complexity similarly consistency on user preference should be maintained and arrangement of content of information with the importance.
4. Perceptible Information: multi-modality input and output helps disable people to perceive and get the information so different modes like verbal, tactile, graphical, speech provide in options which gives multiple options to the users appropriate in their preference. Similarly provide compatibility with different devices.
5. Tolerance for Error: arrange element to minimize errors and provide warning when user make mistakes.
6. Low Physical Effort: design can be made where low physical effort needed to operate by minimizing repetitive actions by using reasonable operational forces.
7. Size and Space for Approach and Use: required or appropriate size is provided and provides clear line similarly, provide adequate space for the use of assistive devices ”.

Different guidelines are mentioned in each principle. In particular, principle fives about "tolerance for error", suggested some guidelines like arrange elements to minimize hazard and errors. This guideline can be implemented in DP user interface to make the element accessible. Similarly, another guideline is discouraging unconscious action in tasks that require vigilance that indicates allow the users correct mistakes without any penalty. These principles may be applied to evaluate existing designs and provide recommendation for universally design system, and services. Similarly, principle six is "low physical effort", which means design should be effective and need low fatigue. In DP web interface, this principle would be implemented which minimize user's effort on proofreading. Moreover, principles of universal design are landmark to design, which makes the system and services easy to use.

There has been a great amount of work on User Interface Design guidelines. In one study, writer Sajedi et al. (2008) described some important usability guideline for user interface design and suggested some guidelines for improvement like consistency, flexibility and efficiency of users, use of color, reduce latency, metaphor and so on. These are the common guidelines, which helps to improve usability. Moreover, they suggested some useful User Interface design guidelines like access control, user control, minimize the user memory load, creating multilingual forms, minimalist design and aesthetic, error handling, anticipation. So, this indicates that minimize users memory load increase usability. Because, users knowledge about the context itself not the way of performing task so, system should be designed in such a way that minimize cognitive load. Moreover, there exists lots of guidelines to design an interface usable, or criteria to design system. Despite of there is still information technology systems with bad usability. (Nielsen, 1996), described heuristics to design usable user interface which are,

- " Visibility of system status"

System should always direct users about what is going on and provide feedback within reasonable time.

- "Match between system and the real world"

Information should be appeared in logical order; similarly, system should speak user's language.

- “User control and freedom”

System should provide freedom to users to perform.

- “Consistency and standard”

The information, situations should have same order always.

- “Error prevention”

User should know about the error before they commit action.

- “Recognition rather than recall”

Minimize the users memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another.

- “Flexibility and efficiency of use”

System should be simple both for novice and expert users

- “Aesthetic and minimalist design”
- “Help users recognition, diagnosis, and recover from errors”

Error message should be expressed in plain language, and help to recover from that problem.

- “Help and documentation ”

Nielsen heuristics are guidelines for user interface design, but some researchers believe that these guidelines are not enough to cover usability. Having said that, the guideline “Recognition rather than recall” mentioned about memory load to design user interface where user should not have to remember information from one part of the dialogue to another. Because working memory cannot hold large information for a long time so minimize memory load maximize usability. In DP web interface, new design can be implemented to minimize memory load because in current DP proofreaders user have to remember large sentences from the image text in one window and compare the editable text to another window to make the comparison or necessary change which reduce usability and increase physical effort.

Similarly, Ben Shneiderman has introduced eight golden rules for user interface design. These principles are derived from experience or heuristically with a, believe that these principles are applicable in most interactive systems to maximize usability. Once again Cronholm (2009) discussed these principles which are:

- “Strive for consistency”

  Consistent sequence of actions should be required in similar situations. Identical terminology should be used in prompts, menus and help screens.
- “Enable frequent users to use short cuts”

  Abbreviation, function keys, hidden commands, and macro facilities are very helpful to an expert user.
- “Offer informative feedback”

  For every operator action there should be some system feedback.
- “Design dialogue to yield closure”

  Sequence of actions should be organized into groups with a beginning, middle and end.
- “Offer simple error handling”

  As much as possible, design the system so that user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.
- “Permit easy reversal of action”

  Action should be reversible as much as possible.
- “Support internal locus of control”

  Experienced operators strongly desire the sense that they are in charge of the system and that the system responds to their actions. Design the system to make users the initiators of actions rather than the responders.
- “Reduce short-term memory load”

Humans has limited capacity for information processing in short-term memory, It has been proved that we can only remember seven plus minus two chunk of information so; designer should avoid the interface where users must remember information from one screen and use same information in another screen. This guideline suggest that, minimized short term memory load gives better usability. When we see the current DP interface, this rule is not implemented in designing where users need to remember information from one screen and compare with another screen which contain same information and make the change if find any mistakes. So, particularly this rule can be implemented in DP web interface to reduce memory load and make the system usable.

These all principles, guidelines, and usability rules mentioned that, memory load can be reduced and is important to increase usability.

3. Research Method and Techniques

User interface has been one of the important aspects in human computer interaction. Wide range of research methods can be used in HCI depends on its problem issue. Lazar, Feng, and Hochheiser (2010) described three empirical investigations in HCI: descriptive investigation, relational investigation, and experimental investigation. They described, researcher determine casual effect between two factors in experimental research where this research enables the identification of casual relationship. Some researcher combine two or even three kind of investigation, where descriptive research provide researcher about future research direction, relational research provide correlation between variables, and experimental research provide casual relations (Lazar et al., 2010) . Basic and applied research can be both quantitative and qualitative (Kumar & Phrommathed, 2005). They described, Quantitative research is basically based on quantitative measurement, which are chosen methods in this study i.e. qualitative and quantitative. Moreover, some statistical operations are performed to analyze collected data. Another scientific research type is qualitative research, which tries to seek the answer to the question, collect evidence. The main strength is can provide descriptive explanation of how people experience on research issue. Qualitative measurement might not give satisfied results every time so; qualitative method has been adopted in this study to get the descriptive result from the participants.
Another approach of research is discussed by Sjoberg, Dyba, and Jorgensen (2007) is empirical, that seeks to describe, explore and explain the natural, social or cognitive phenomena by evidence based on experience or observation. Which means, evidence can be interpreted by experiment, observation, interview, survey and so on. For collecting and analyzing the data, both qualitative and quantitative methods can be incorporate with empirical approach. Quantitative method collects numerical data and analyzes it using statistical methods while qualitative methods collect information in the form of image, text, sounds based on interview, observation where data analyzed using opinion or without any statistical operation performed.

In this study empirical method has been used to get the evidence for the study for doing this, prototypes are evaluated through real users and data collected have been analyzed and discussed.

Both qualitative and quantitative methods have their own benefits for conducting research. Quantitative research is based on the something that can be measured where qualitative research cannot accurately measure. The advantage of quantitative method is researcher can interpret the result obtained by participants using some statistical measurement. While qualitative method is more flexible for users, which means this method ask open-ended questions to the participants and not necessary to have similar set of response. So, the advantage of qualitative method is participants have their own choice to answer the question or they have more freedom than focusing on selected set of response.

Software and web site can be evaluated using different techniques. In one study Jeffries et al. (1991) evaluated the software with four techniques: heuristic evaluation, usability testing, guidelines and cognitive walkthrough and made their comparison where they found heuristic evaluation was best among them because they have best experts to evaluate through this approach. Similarly, Lazar et al. (2010) explained types of usability testing in their book. Where testing is divided in three distinct categories: expert-based testing, automated testing, and user based testing. The common expert based evaluation is heuristic review, the consistency inspection, and cognitive walkthrough. In heuristic evaluation, expert takes the set of heuristics and compare with interface, like; universal design principles can be the heuristics. In consistency inspection one or more experts review series of web pages and in cognitive walkthrough experts simulate users a series of tasks (Lazar et al., 2010). In automated testing, usability of the web page is evaluated by software application. Third technique is user-based testing also refer as usability testing. Lazar et al. (2010) described different types of usability testing: formative testing, summative test, and validation test. When testing is takes place early stage of development like this test may include wireframe or paper prototype. Similarly, when more formal high level design available then summative test takes place like, evaluating functional prototype. Similarly, test takes place just before the release of final interface is called validation test.

In one study, Wang and Caldwell (2002)compared heuristic evaluation and user testing with empirical study where these two methods were compared in terms of efficiency, effectiveness and cost benefit analysis, and they found heuristic evaluation is better to find usability problems where user testing was better to find major problems like, provide insight data on users performance and satisfaction but heuristic evaluation found more cost effective. It shows that both techniques have their own advantage and disadvantages. For universal design, user-based testing would be more useful to find the users behavior, their performance and satisfaction on system so that, user- based technique has been used to collect the data from both the prototypes. Moreover, the methodology used is discussed in the next chapter “Research Methodology”.

4. Design and Development

Development and evaluation of crowdsourcing application in the context of the universal design is the aim for doing this research. So, one of the crowdsourcing application which is Distributed Proofreader (DP) is chosen. Distributed Proofreader provide is a web based method to ease the conversion of public domain book to e-books where, many volunteers can be able to work on a same book at a same time which is the main aim to speed up the proofreading. During the proofreading, proofreaders provided with the scanned version of page and corresponding OCR text on a single page with different windows. This allows text to be easily compared, proofread and send back to the site. So, in this study aim to design and develop the user interface where volunteers can easily proofread the text or easily compare the OCR converted text with the original image text. Moreover, how can we make the DP user interface universally design and increase the overall usability of the system is the aim of the study.

Literature review is done to find the universal design, accessibility and usability of the system similarly; universal design principles, accessibility principles and guidelines are presented to understand the insight for web and its importance in Web. Moreover, cognitive load is emphasized in this study because proofreading portal is more related to the memorization of the content so, universal design is possible by applying cognitive load theory which means reducing memory load increase performance and vice versa.

Some of the universal design principles were applied while designing the prototype like, color, font size and more emphasis is given to the cognitive load so, prototype is developed in such a way that participants can easily check the original image text and proofread or able to find the error easily.

4.1 Design Concept

While designing the prototype, literature review is done to investigate the universal design of the web through its principles and cognitive load theory is discussed and prototype is designed. At the first Requirement are gathered on paper from the knowledge collected, after gathering the requirement, design concept is implemented on prototype. Before the user testing all possible way for making the prototype universally designed is completed and developed interactive prototype.

This design concept of DP user interface has been taken from the work of Pietro Murano who is the supervisor for this research. Moreover, some design concept is taken from his work like text field, buttons which is shown in figure 4.2 in the layout of newly proposed prototype and additional universal design concepts like font color, font size has been added on it through other related literatures.

Memory load can be reduced by reducing the memorization like, in existing DP user interface users or volunteers need to see text in the one window and correct the errors according to original image content which contains long sentences where users have more stress in their mind and they might forget some information so, in new prototype the user interface is designed in such a way that the whole text is available in different lines where users can check each lines and make changes in next line in OCR converted text as shown in figure 2. Once they finish with first line they can go into second line and continue the process till the end. Moreover, the aim of redesigning the prototype is to make the interface easier and simpler for the users so, proofreading is possible in single lines where whole book has been separated in to different line and proofreading is available in corresponding lines. Because, human mind is only capable of holding or memorizing limited information at a time so, designing in such a way, users

only need to memorize or see one line at a time and jump into the next line might be easier to memorize.

Before developing the design concept of new prototype the universal design issues of DP user interface is analyzed. For doing these universal design principles are studied and cognitive load theory is discussed in literature survey which gives some possible changes to make universally designed system.

When increasing the font size and appropriate color makes the user interface more universally designed which is also mentioned in the accessibility so, this concept is implemented in the design of the user interface. Similarly, it is said that human mind only can hold limited text at a time so designing the prototype, tried to limit the sentences in one field and divide the whole text in to different fields which will be easier for users to memorize the sentence and correct the error or compare with the image text. Moreover, two prototypes are designed and developed i.e. one is existing DP user interface is similar to the portal interface and another is newly proposed DP user interface. Before developing the prototype, all those mentioned design concepts are collected in the paper and then after implemented in the development phase. Moreover, for designing the prototype, requirement are gathered through existing DP user interface or more specifically, universal design, and accessibility issues which are also mentioned in the literature review are discussed and tried to change this portal in to another form so that users can be easily work on proofreading operate effectively and efficiently. Some of the issues found in the existing DP user interfaces are font size of the functionality or buttons similarly, arrangement of image text field and OCR converted text field. In existing DP user interface, whole text is available in the same field so, user get confused sometime where he/she is now and can be chances of missing some sections while blinking the eyes. So, while designing the new way for this problem here tried to separate different lines where users can finish one line at a time without any interruption. New prototype is designed on this concept and developed which is discussed in the next section.

While designing the prototype Agile method has been adopted and prototype is developed through SCRUM. Requirements are gathered through literature review at the

beginning and implemented in the system. Font size, font color are added in the system. All the tasks and deliverables were mentioned and implemented accordingly. Moreover, the first task for prototype design was “text line”, in this task the deliverables were to arrange the text in different line and finally one line text for corresponding original image text is chose. Similarly, for the color of the proofread text, different possible colors are selected and chosen appropriate. SCRUM board is prepared on paper where, deliverables are presented accordingly like, design concept is prepared on the paper once when finish with the design concept then, tasks are presented in sequences and implemented on design accordingly. Moreover, for designing the existing prototype, similar user interface was designed and developed. But designing newly proposed prototype, different universal design aspects were took in to account and implemented accordingly.

AXURE prototyping tool has been used in this study to develop prototypes where an interactive prototype has been developed and participants were asked to perform given tasks on both the prototypes. ("Design the Right Solution,") said that, AXURE was released first 2003 and has been used in prototyping and wireframe. It allows non-programmers to build interactive prototypes and wireframe as their requirements.

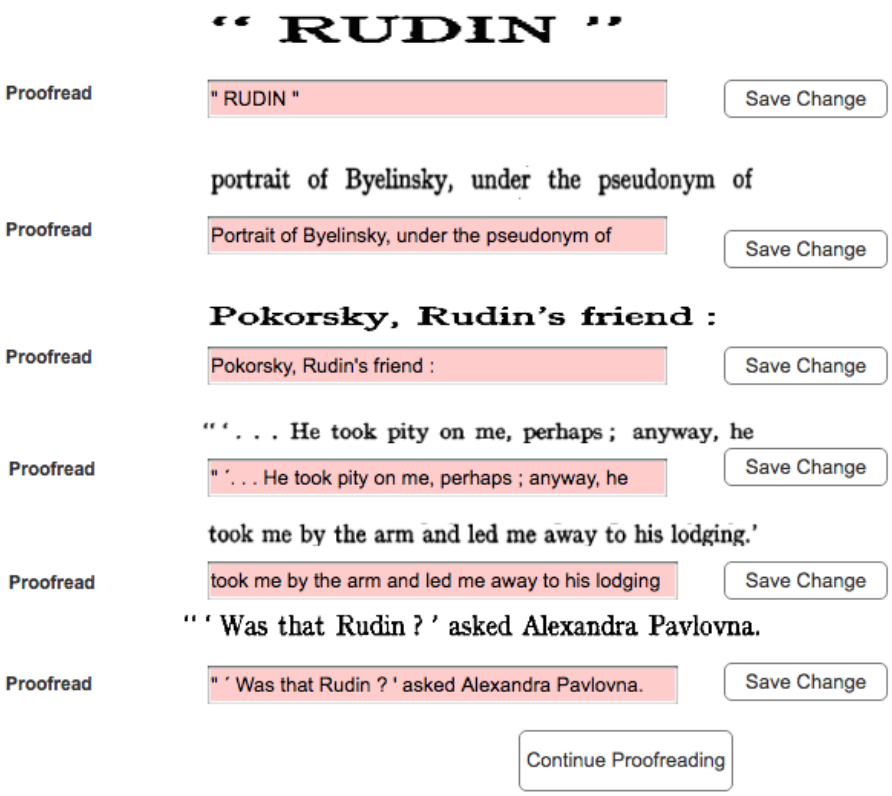

Figure 4.2: Layout of the newly approached prototype

This newly designed concept was tested with the users as compared to existing user interface and if user prefer this newly approached prototype then this concept can be implemented in real life.

4.1.1 Prototype Development

Tried to find out the errors in the DP prototype and other universally designed issues in the DP user interface is the aim for doing this research so, prototype is designed and developed to test this study through the participants. After finding out some universal design issues in DP user interface then, new prototype is developed with some changes like, color contrast, font size, and more importantly the windows for image text and edition.

After sketching the design concepts for prototype, those concepts are implemented in the real life by developing the interactive prototype. For developing the prototype Axure prototyping is used to develop an interactive prototype where participants can perform some task to conduct the experiment. Moreover, all the design concepts discussed in the design part are implemented on the development and the final product is ready to use and ready for the evaluation and user testing. Following figures 3 and 4 are the developed prototypes having different functionality. In those prototype participants can interact for doing the given task, which is the aim for developing the prototype. Figure 3 shows the layout of existing DP user interface where prototype is build as same as DP user interface. Similarly, figures 4, 5, and 6 shows the layout of the newly approached DP user interface having different design as compared to existing DP user interface. In new design each line of the paragraph is separated in the single line where single line image text and OCR converted texts are available one after another, similarly the saving option is available in the right side of the box would be easier to the participants. Similarly, soft pastel colors has been used in OCR converted text field, which are, preferred color by cognitive impaired persons Rello and Baeza-Yates (2013). Moreover, “continue proofreading” button is appeared in the end of the page like wise, “back to previous page” and “continue proofreading” buttons are appears on end of the second and third page. Universal design of the system and web is studied before developing similarly; cognitive load theory is also briefly discussed and then only entered in to the design phase to design the prototype accordingly.

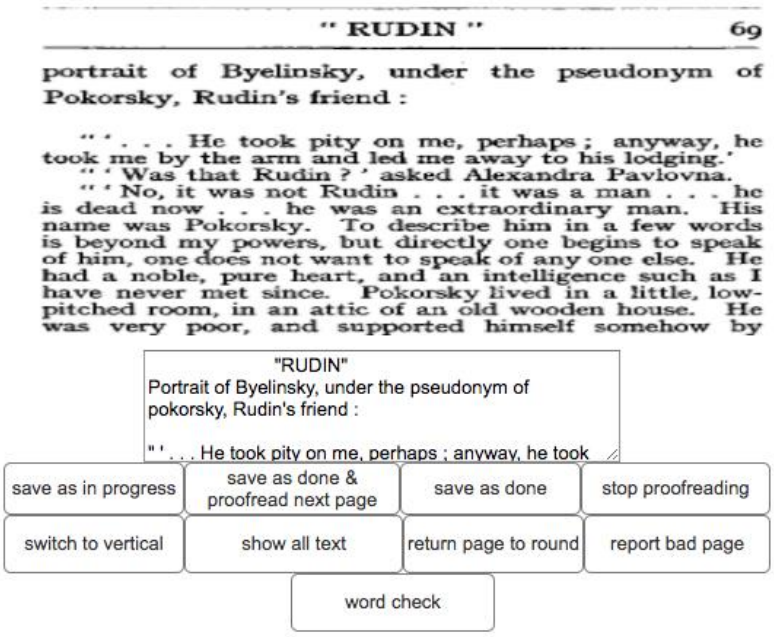

Figure 4.3: layout of existing DP user interface

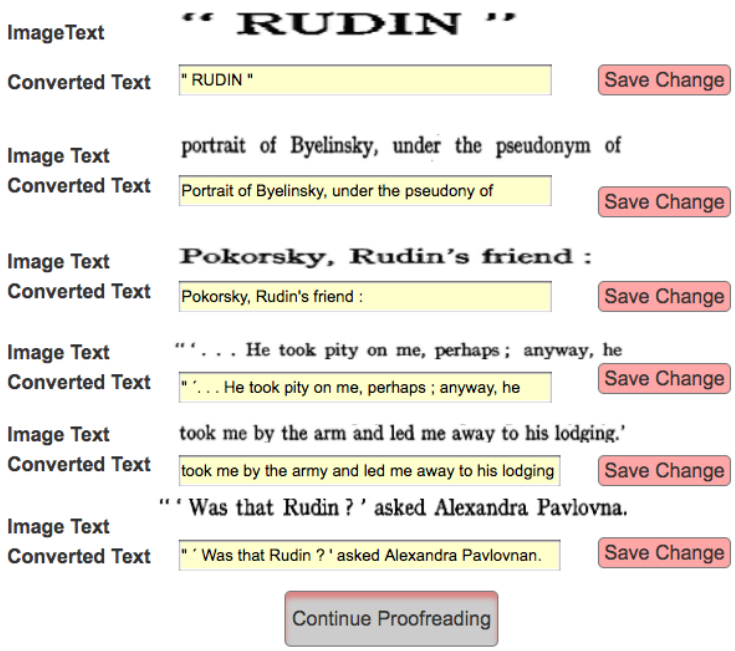

Figure 4.4: layout of newly approached DP user interface

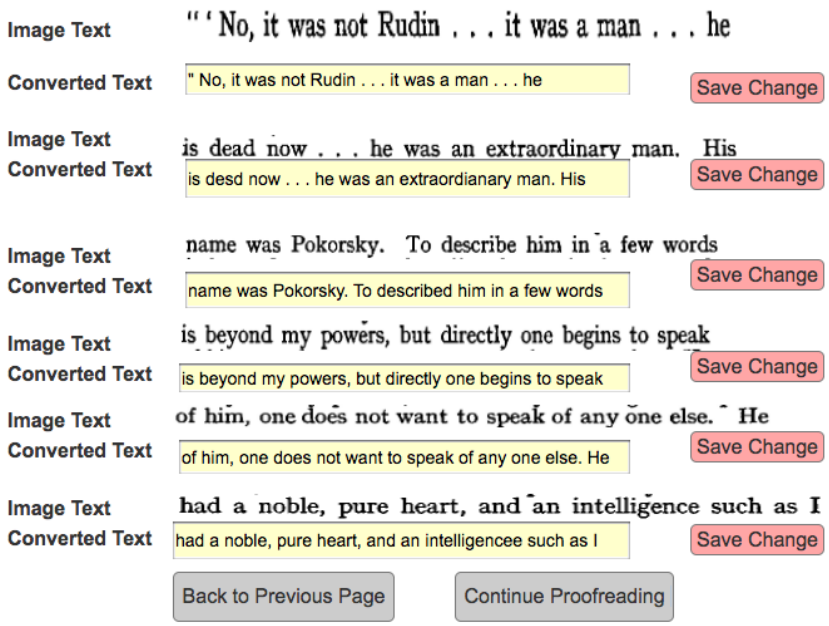

Figure 4.5: layout of newly approached DP user interface

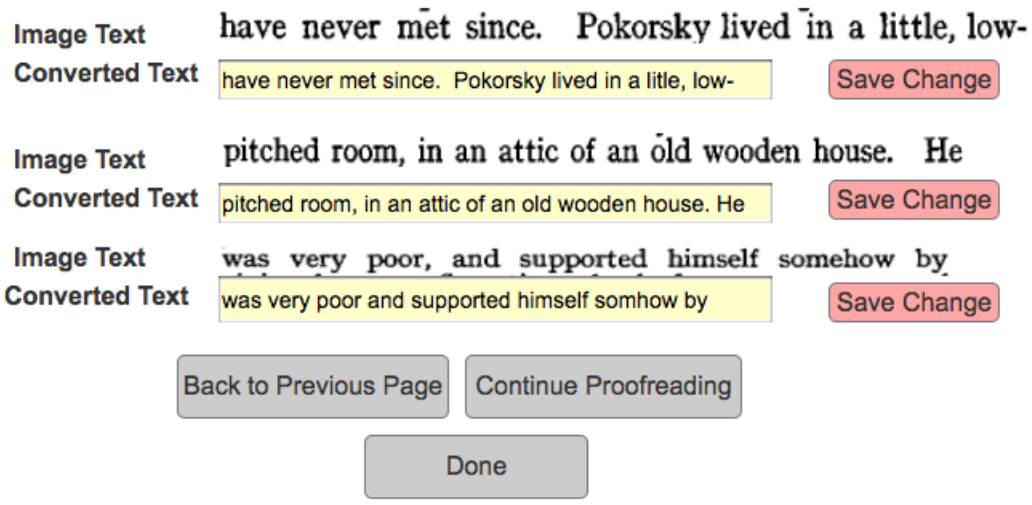

Figure 4.6: layout of newly approached DP user interface

For developing the prototype, Axure prototyping tool is used to get the user experiences. By using Axure an interactive prototype is developed according to design aim to evaluate through the users. Axure is a prototyping tool aim for web and desktop applications.

Dyslexia (cognitive impairment)

Dyslexia is also called reading disorder, but not the intelligence, which is common in many people. There is not any particular definition of dyslexia Westby (2015) discussed different myth of it. Common characteristics of dyslexia are mentioned by LoGiudice (2008). Some in reading, writing, and spelling are

1. Difficult in reading unfamiliar words.
2. Avoid reading out loud. Dislike the public speaking.
3. Frequently has to re-read sentences in order to comprehend.
4. Poor handwriting. Masks spelling mistakes.

These are some characteristics of dyslexic adult person so, when these people interact with the system they or involve in proofreading then that would be the challenge for them so, this newly proposed DP user interface is designed by keeping these issues in mind. And to evaluate the prototype 2 people having these kinds of problem are participated in the study.

4.1.2 Graphic Design Decisions

Color: dyslexic people like cream color or soft pastel color (Rello & Baeza-Yates, 2013), which is used in the prototype, but some dyslexic people have their own color preference .

Font Size: font size is used with 14 for the text and 16 for buttons. W3C mentioned that font size should not be too small in default. Similarly, WCAG guidelines recommended ensuring that text should be zoomed to 200% ("Web Content Accessibility Guidelines (WCAG) 2.0,").

5. Research Methodology

User-based technique is employed on evaluating interfaces for universal design. In one study Wang and Caldwell (2002) said that, user testing is best way to identify the real problems that impact users performance and preferences. It shows that, system will be universal design and inclusive when tested with the real users. Furthermore, for evaluating the prototypes both qualitative and quantitative nature of data is collected from the participants. Because, different kinds of data can be collected during the usability testing for universal design; the common quantitative measurements are task performance, time taken, and user satisfaction (Lazar et al., 2010). In universal usability testing, qualitative data is also important. “Think aloud” is common in user interface evaluation as user are going through the interface where they state their feelings, frustrations and progress out loud (Lazar et al., 2010).

Different quantitative data collection methods can be used for evaluation like surveys, questionnaire, observation (Allen-Meares & Lane, 1990). Questionnaire is a set of questions for getting the information from participants, which is, approached methods in this study. A questionnaire is a data collection tool in a written format; this method is chose because of its advantages. Like, focused for target users and clearly defined question, collect quantitative data (Marshall, 2005). In questionnaire range of questions can be asked like, closed questions, categories questions, ranking/scale, list (Marshall, 2005). Likert-scale questionnaire is used in this study where participants chose ranked option from the given list. Furthermore, it does not force participants to answer, allow them to answer in scale; similarly, this method is inexpensive and effective for data collection.

In this study universal design principles are implemented in the user interface prototype and evaluated through the experiment, where certain task are given to the participant to complete in prototypes and questionnaires provided to find the satisfaction, efficiency and effectiveness for making the user interface accessible for large number of users and improve usability and universal design.

For collecting quantitative data, had a set of post-task usability questionnaire regarding the universal design of user interface where participant’s answers in different scale will

be analyzed and interpreted. System usability scale (SUS) is applied for measuring the usability of the both prototypes. It contains ten questions with five responsive options for participants from strongly disagree to strongly agree (Dianat, Ghanbari, & Asgharijafarabadi, 2014). The strength of this method is easily differentiated the usable and unusable system and interface.

Different research method can be applied on Human Computer Interaction (HCI) research. In this study both quantitative and qualitative approaches are applied to collect the data. For collecting quantitative data from the participants an experimental method is applied.

Eleven participants were selected for evaluation. In this research, all the participants participated were university-going students having good knowledge to use of the system, i.e. they use computer and other electronic devices regularly. Moreover, to make the study more inclusive, both man and women were selected asked to participate having different age group and cultural background. SUS questionnaires can give good results even in small group of users like in this study. User participated in the research may not represent whole population but for especially in this study, the DP user interface is platform for the interested volunteers around globe via internet where computer literate only involve so, these participants may be able to represent this user group. Moreover, diversity is maintained while choosing the participants like, participants involved from different cultural background, different gender, and cognitive ability.

Another approach of research is discussed by Sjoberg et al. (2007) is empirical, that seeks to describe, explore and explain the natural, social or cognitive phenomena by evidence based on experience or observation. Which means, evidence can be interpreted by experiment, observation, interview, survey and so on. For collecting and analyzing the data, both qualitative and quantitative methods can be incorporate with empirical approach. Quantitative method collects numerical data and analyzes it using statistical methods while qualitative methods collect information in the form of image, text, sounds based on interview, observation where data analyzed using opinion or without any statistical operation performed.

Empirical approach is applied to conduct study from the beginning where empirical evidence were collected through the experiment, by involving individual to the evaluation process like, user-based evaluation be useful to evaluate user interface prototype (Xu & Skov, 2007). Where evaluation will be more effective and accurate because of the involvement of the real users in the testing. Moreover, response from real users gives better result and accurate result as compared to other evaluation methods like, heuristic evaluation, and others. So, empirical method found appropriate for conducting the research so that, implemented on this study.

Both qualitative and quantitative methods have their own benefits for conducting research. Quantitative research is based on the something that can be measured where qualitative research cannot accurately measure. The advantage of quantitative method is researcher can interpret the result obtained by participants using some statistical measurement. While qualitative method is more flexible for users, which means this method ask open-ended questions to the participants and not necessary to have similar set of response. So, the advantage of qualitative method is participants have their own choice to answer the question or they have more freedom than focusing on selected set of response.

5. 1 Quantitative Research Method

The objective of this study is to investigate how cognitive load can be minimize in DP user interface and make the system universal design so, doing this research an experiment is conducted with participants and tried to answer the research question and hypothesis. System Usability Scale (SUS) is used which is a set of questionnaire having ten questions with five response option from one to five where one stand for strongly disagree and five is strongly agree. These questionnaires give the quantitative nature of result, which are discussed in next section briefly. Similarly, demographic questions asked before starting the task give some quantitative data.

5. 2 Interview

Users feeling towards the system are very important to collect correct information in the research so, in this study a short interview is conducted with participants to find their feeling towards the system and to know their level of satisfaction and difficulties, which was conducted, at the end of the task. In an interview one way interview is conducted which is very short interview at the end of the task gives some facts.

5.3 Mixed Method

Both quantitative and qualitative data are collected in this study to find the users perception and preferences on the DP user interface that is from existing DP user interface and newly approached interface. For collecting required data an experiment is conducted where participants are participated to perform the task. Participants were observed during the experiment gives some qualitative nature of data similarly; think aloud method is used to collect qualitative data during the task where users feeling towards the system are noted.

6. Experiment

The experimental set up of this study is similar to the real life experience where, interactive prototypes were tested among users in a similar environment. The evaluation of the prototypes is to see the efficiency, effectiveness, user satisfaction and overall universal design.

Same condition is provided to all eleven participants to make the experiment real and unbiased for all. Same device is used to evaluate the prototype among the participants aiming to get accurate result without any interruption. There are two prototypes available for each and every participant where one participant participates at a time, which applied for rest of the participants also. Moreover, a comparative study is done between two prototypes to find the users preferable system by involving participants in both prototypes. Moreover, participants were asked to perform in both prototypes to

finish given task, which is analyzed in next section. Similarly, equipment used, task given, experiment scenario is discussed briefly in next section.

6.1 Participants

Total eleven participants are participated in the evaluation of the system where, five students are studying master degree in Oslo and Akershus University College of Applied Sciences and six are master degree students from Oslo University where overall 8 male and 3 female. Among of all these participants, two participants said they find difficulties in concentrating in difficult words and try to skip those complex words and complex sentence. So, these two participants involved in this study having some level of cognitive impairment.

Table 6.1: Participant's characteristics

Participant	Age group and Gender M/F	Computer using behavior	Disabilities
1	20-25 M	Everyday	None
2	20-25 M	Almost everyday	None
3	25-30 M	Everyday	Low vision
4	25-30M	Everyday	Low vision
5	20-25 F	Everyday	None
6	25-30 M	Everyday	None
7	20-25 F	Everyday	None
8	25-30 M	Everyday	Learning difficulties
9	25-30 F	Everyday	None
10	25-30 M	Everyday	None
11	20-25 M	Everyday	Learning difficulties

Participant participated in this study aging between twenty to thirty among of them some users are facing some minor disabilities are presented in table 1.

6.2 Equipment used

- MacBook Air 13” for performing the task
- Stopwatch to record users task completion time

MacBook Air 13 inch has been used during the task where users had performed given tasks, which was similar to all the participants in a similar environment. Two participants performed the task in the HIOA library and other nine users were asked to participate in the study in their residence. Each and every participant has had good experience of using the computer makes easy to conduct the experiment because they are familiar of using computer devices and other electronic devices like, smart phone. The computer that I have been using is used for this study as equipment for data collection. For calculating the completion time during the prototype-testing stopwatch has been used as a tool. Stopwatch has been used to calculate the completion time.

6.3 Steps of experiment

For conducting the experiment the following steps were followed

1. Explaining the tasks and experiment to the participants and sign on consent paper.
2. Questions on demography: age, gender, and access of computer, use of computer and Internet in daily life.
3. System Usability Scale (SUS) questionnaire at the end of the task.
4. Short interview on participants thought on user interface prototypes.

In the first step Both the tasks are explained briefly to the participants in the beginning of the experiment similarly, before starting the experiment written consent form was

introduced to the participants and given to them to understand and sign on it for their approval which describes about the research and what is this system is all about and what kinds of data are collecting during the session.
After that, in the second step, some questions like age, gender, and their computer access behavior are collected through written questionnaire, which are discussed in the evaluation section. Similarly, System Usability Scale (SUS) was used as a post-task questionnaire for finding the usability of the system which contained ten questions where participants had to rate them in five responsive options from one to five where one indicates strongly disagree and five is strongly agree. These SUS questionnaire used for system effectiveness, efficiency and users satisfaction regarding the system. Where, five questions being asked positively and rest five questions are being asked negatively. After getting response from users these results were discussed in the next section in evaluation and result part. At the end short interview was taken having two questions about users feeling towards both the user interfaces and their preferences of using them. All the participants were aware about the all above-mentioned steps before conducting the prototype testing.

6.4 Experiment Scenario

1. Explaining about the experiment to participants about 3 minute.
2. Giving task to perform on both prototypes.
3. Short interview to the participants about their impression using the system.

All eleven participants were participated in the task in different time where three minute was given to individual participants before starting the task to inform about the study. The users involved in the test were all computer literate, college going students having computer skills so; it was easy to explain to them and three minute time was enough to explain about the research. After explaining the task to the participants they were asked to perform given task and observed closely where both prototype i. e. existing DP user interface and newly proposed DP user interface were given to them one after another.

6.4.1 Tasks

Participants are asked to complete the pre- prepared tasks, which were aimed to check the universal design of the user interface. Before starting the task participants were given some time to be familiar with the system, once participants get ready for the task then task started and this applied to all the participants. Participants are asked to complete the task in both interface prototypes where task was to proofread the OCR converted text according to original image text and use the functions appeared on the user interface. Following tasks were given to the participants to perform in the interface.

1. Check the errors
2. Use some functionalities

Task one: in the first task all the participants were asked to complete the proofreading in both prototypes and observed closely during task which gives the some information regarding their difficulties and performance. Moreover, all the participants had to interact with the system to complete the proofreading where in the existing proofreading only one page is available and in the newly proposed system participants had to go through some clickable buttons to complete the task. During the task if something difficulties happened with participants were noticed.
The aim of performing this task was to check the errors on the OCR converted text so, user had to compare the OCR converted text to the original image where time taken during task performance is also measured which gives the usability of the system. Finding errors on OCR converted text is the main goal of this research so; participants had given to find the possible errors at a time.
In this task, for newly proposed DP user interface, all the participants had managed to complete the task but completion time was different. But in the existing DP user interface, not all participants had able to found errors in once. Only three users were able to manage the task and found all possible errors in the OCR converted text and remaining users were failed to found the errors in once.

Task two: in this task, all the users were given a goal to find the difficulties and easiness on the font color and font size in both prototypes. For performing this task users had to start with the page and navigate the page to perform like, save the page, continue proofreading aiming to make the user interface more usable and universally designed. In this task used had to select some buttons in both prototypes one after another and encouraged to speak out something if they found some difficulties which were noticed.

In this task, in both prototypes, all the users had managed to perform the task but their preference were different and label of satisfaction is different which is discussed clearly in evaluation section.

Overall, all the participants were able to manage to complete the given task but their task completion time were found different and their preference were also found differently. Think aloud method has been used in this study to get the users feeling so, their thoughts and feelings regarding user interface were collected during the both tasks i.e. task one and task two.

6.4.2 Interview

The following questions are asked to the participants after performing the task.

1. What is your overall feeling about the both user interfaces?
2. Which user interface you found easy to use?

Think aloud method is used during the task if users had to say something about their feeling towards user interfaces so very short interview was taken to get more data for the study. Those interview questions covers the aim of the research and helps to make the research more standard. The first question, “what is your overall feeling about the both user interface” covers users feeling towards the system and participants respond their feelings towards the user interface. Different users have not similar answer of this open question but almost all replied on their preferences of using the system for this question. For the second question, “which user interface you found easy to use” all

eleven participants responds were agreed on newly proposed DP user interface gathered data for result.

Above asked questions in the short interview gave qualitative data, which are discussed in result and discussion section to give justice on the research, which is chosen methodology for this study.

7. Evaluation

For evaluating the prototype participants have asked to interact with the prototype to perform some given task and short interview at the end was performed.

Quantitative Result

Quantitative data are collected during the experiment and after the task completed by the participants. Before conducting the experiment each participants filled the questionnaire containing six questions containing some demographical questions and some questions related to their using habit of computer and Internet, which gives some data, which helps to analyze the result. Each participants have asked to check the errors in both prototypes where all participants found newly proposed prototype is easy to find the errors as compare to existing DP user interface portal. When all participants complete the task some questions are asked to know what they feel about the both interfaces. The question 1, asking what is your overall feeling using both user interfaces, and all participants had same answer on error checking they said in newly proposed user interface it was easy to proofread. 6 out of 9 participants said that, there is not difference in other functionalities. The second question asked was which user interface is easy to use, once again same result was found all the participants said proofreading is easy and fast in newly proposed system. This indicates that, keeping both windows i.e. original image text and OCR converted text is perceived very positively. Quantitative data is collected through SUS questionnaire, which was given to the participants at the end of the experiment. The SUS questionnaires having ten questions and participants have to response on 1 to 5-likert scales where 1 represent strongly

disagree and 5 is strongly agree. The following table contains questions and participant's response on these questions.

Table 7.2: SUS response table for existing DP user interface

ID	Questions	Response
1	I think I would like to use this interface frequently	4
2	I found the interface unnecessary complex	3
3	I thought the interface was easy to use	4
4	I think that I would need the support of a technical person to be able to use this interface	2
5	I found various functions in this interface were well integrated	3
6	I thought there was too much inconsistency in this interface	1
7	I would imagine that most people would learn to use this interface very quickly	3
8	I found the interface very cumbersome to use	1
9	I felt very confident using this interface	3
10	I needed to learn lots of things before I could get going with this interface	2

All eleven participants were asked to respond on likert-scale and response was recorded and presented in table 2 and table 3. For presenting the preferred likert-scale the averaged response is calculated and presented on the table, which is shown in table 2 and table 3.

SUS response got from the users was calculated. Sauro (2011) where calculating SUS is given where point 68 considered as average, below 68 is below average and above 68 is good having usability and user satisfaction. In existing DP user interface system usability scale score is 70, which indicate that this system is usable. All eleven participants have more or less similar thoughts regarding the each asked questions.

However, two participants said they have difficulties remembering long and difficult sentences answered differently than other participants.
The overall usability scale score is 70, which shows that system usability is good.

Table 7.3: SUS response table for newly proposed DP user interface

ID	Questions	Response
1	I think I would like to use this interface frequently	4
2	I found the interface unnecessary complex	1
3	I thought the interface was easy to use	5
4	I think that I would need the support of a technical person to be able to use this interface	2
5	I found various functions in this interface were well integrated	5
6	I thought there was too much inconsistency in this interface	2
7	I would imagine that most people would learn to use this interface very quickly	4
8	I found the interface very cumbersome to use	2
9	I felt very confident using this interface	4
10	I needed to learn lots of things before I could get going with this interface	3

The system usability scale is obtained 82.5 after calculating through the users response indicate that, this user interface is preferred by the participants and found easy to use. All the participants agreed on that this user interface is easy to use which was asked in question 3.

Qualitative Result

Participants are asked to use think aloud method while interacting with the interface. Moreover, participants are observed during their task performance. Both the interface prototype was introduced to users before performing the task so all the users has their feelings towards the interface. In first prototype, that is in existing DP user interface all participants said, “Bit difficult to concentrate” during error checking or proofreading. Similarly same of the user said, we need to zoom in font size it is confusing. One participant said how difficult to concentrate on proofreading. Moreover, some of them express thought on font size and buttons said why don’t they use different colors on the clickable buttons.

Similarly, when participants are asked to perform on newly approached DP user interface, all participants seem able to find the errors easily and one participant said so simple, next participant said “easy to use at least than first one”.

Asking some questions at the end of the task was also gave qualitative result like, the question one, what is your feeling toward interface which applied for both the prototypes and got mixed reactions from users. One participant said, proofreading is easy in newly proposed prototype because it was simple where I did not concentrate to remember which is easy. Similarly another participant said proofreading three lines at a time would be nice in newly proposed interface. Almost all participants said it was difficult to correct the errors in first user interface, which is in existing DP user interface. Which indicates that there is room to improve in this user interface. Most participants said button size and color used in second prototype feel easy and simple. When asking second question which user interface is easy to use, all participants said they preferred second user interface for checking the errors and using other functionalities.

System Usability Scale (SUS)

Kothainayaki, Sivakumaren, and Gopalakrishnan (2012) said that SUS is relevant when two products or services are compared. Moreover they discussed SUS gives freedom to choose the appropriate sentences like in the place of “software”; we can use “system”, “hardware” as our needs to make the questionnaires appropriate in the context. Writer

Sauro and Lewis (2011) said that, they found the result obtained from research: participants gives slightly lower rating to the even number statements which is negatively phrased items i.e. question 2, 4,6,8 and 10. Which means participants agreed slightly more on odd number statements. This suggests that participants slightly agree on negatively worded statements.

System Usability Scale (SUS) is commonly used, freely distributed and reliable questionnaire consisting 10 questionnaires, where usability score from 0 to 100 as 0 indicates no usability and 100 indicates maximum usability where, participants have choice to rate from 1 to 5 where, 1 is strongly disagree and 5 is strongly agree (Sauro, Green, Bacon, Matusiak, & Zhang, 2016). They said that John Booke initially developed SUS and have 5 scale points. The SUS questionnaires are as follows.

("Improving the User Experience,") Said that SUS provides quick and reliable tool for providing the usability consist of 10 item questions having five response options for the respondents from strongly disagree to strongly agree. Moreover, it allows to evaluate wide variety of the products, services, user interface and many more including web pages, hardware, software. They also mentioned the benefit of the SUS evaluation, which are:

1. It is a very easy scale to administer to participants.
2. Can be used in small sample size with reliable results.
3. Is valid-it can effectively differentiate between usable and unusable system.

They also mentioned some consideration need to be keep in mind, which are:

1.The scoring system is not easy.

2. Score is from 0 to 100, which is not a percentage.

("Improving the User Experience,") said that, SUS score above 68 would be considered above average and below 68 considered below average. So, when the usability is calculated above 68 for any software, hardware, and system considered good usability and below 68 shows poor usability.

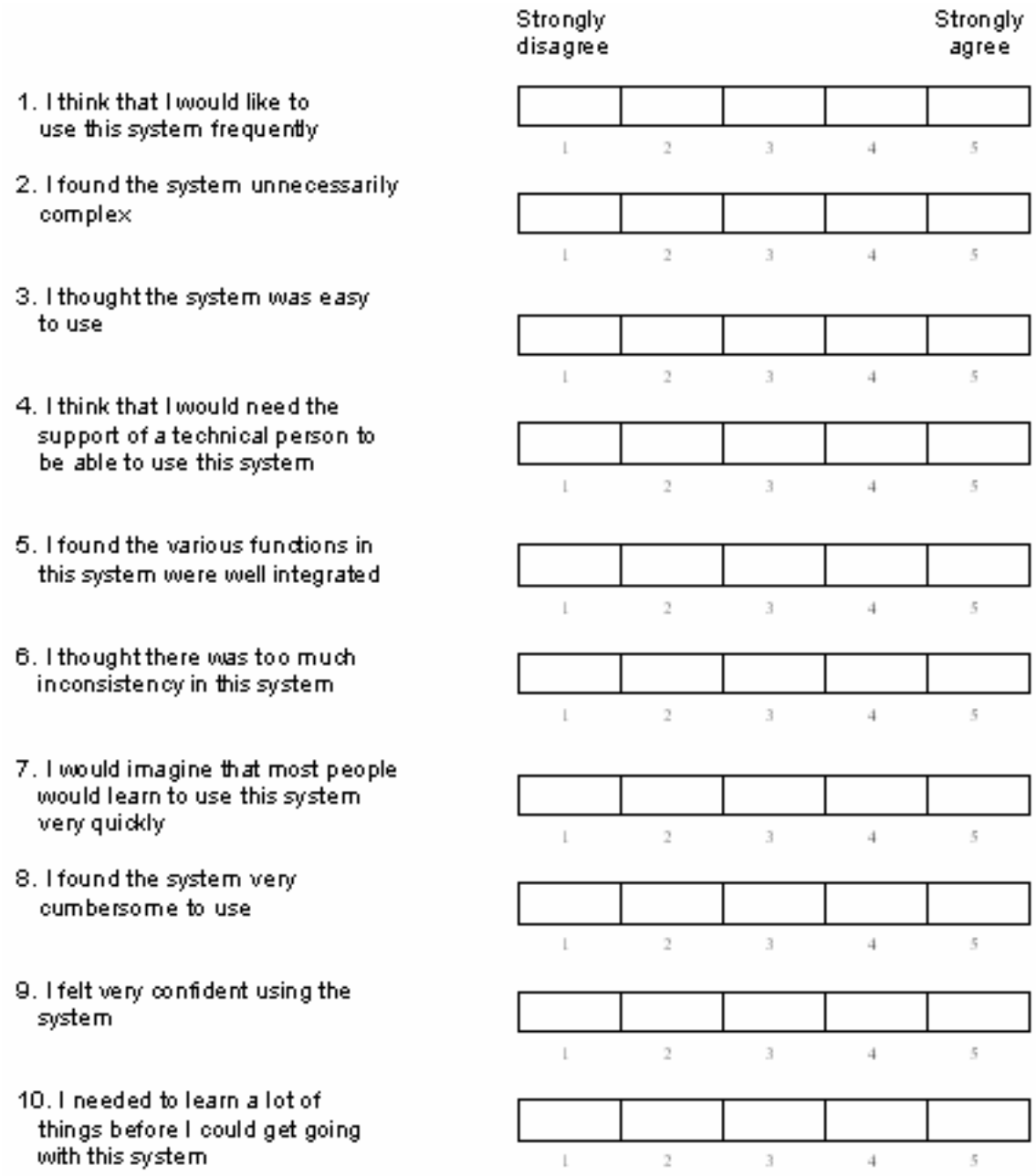

Figure 7.7: SUS questionnaire

Sauro et al. (2016) said that, some words used in the questionnaires makes difficult for the participants to understand specially, for the non- native English-speaking participants. Like in the question 8 there is word “cumbersome” which might be difficult word for may. So, this can be replaced by easy word to make easier for the participants.

8. Analysis

The aim of this project is to identify the universal design problems in the existing DP user interface and design and develop more universally designed, usable and accessible prototype. Moreover, cognitive load theory is discussed and tried to implement the concept of cognitive load theory in the new prototype and some principles of universal designed is also implemented in the prototype. For evaluating the both prototypes a comparative study is done which gives participants favorable system to use.

In this section final evaluation is analyzed. Moreover, comparative study is done to analyze the data collected from both prototypes. It can be seen from the table 1 and table 2, there is no more difference in users response but table 2 shows that, participants prefer newly approached prototype slightly more than existing DP user interface prototype. This result obtained because of the participants having good knowledge on computer and better understanding of using the interfaces like these. Both the prototype has good usability but newly proposed prototype has slightly greater usability scale obtained, which indicates participants preferable system. Moreover, in the both prototype, users asked to check the errors and all the participants able to find the error easily. In existing DP user interface 8 participants were able to find the errors in first chance but in the newly approached prototype, all 11 participants were able to find the mistakes on the OCR converted text, which shows this prototype is easy to use. Furthermore, proofreading time was also noticed while participants performing on both prototypes and found that in existing DP user interface users finish the task slightly faster than newly approached prototype like, participants took three minute and 16 second to finish the error checking task in newly proposed DP user interface but the same participant finish the same task in 2 minute 40 second and similarly, other participants able to finish task slightly earlier in existing DP user interface as compare to newly approached prototype.

According to the result got from the study, it can be said that errors can be emitted easily in the newly approached DP user interface similarly, more usable and universal design. Bigger font size and appropriate font make the system more usable and

universally designed. Furthermore, different color used in the buttons and background makes easier for dyslexic people.

For analyzing qualitative data collected from the user testing through short interview and think aloud method are discussed here. For answering the first interview question “What is your overall feeling about the both user interfaces ” participants answers differently. More specifically, two users did not found any difference between both the user interfaces and remaining nine participants respond that they felt more easier in newly proposed DP user interface as compare to existing DP user interface. Moreover, these nine users were able to found errors in newly proposed DP user interface indicate that they prefer more universally designed system for proofreading. However, two participants said that they did not found any specific differences in bot the prototypes indicate they are comfortable with both the systems. Participant eight and eleven had been facing some learning difficulties said they found newly proposed prototype easy to use because it was hard for them to concentrate on paragraph and easier on single line which was in newly proposed DP user interface. However, they didn’t like the buttons at the end of the each line what they found was disturbing and repetitive which made uncomfortable and irritating. Furthermore, font size and color used were found comfortable and appropriate in the newly proposed DP user interface compare to existing DP user interface. Participants three said that, its really boring to check the errors in the existing DP user interface as compare to newly proposed DP user interface he added buttons are also confusing and size of the fonts are really small but in the newly proposed DP user interface felt more confident and comfortable to navigate. Overall feeling of the participants found different but most of the participants found newly proposed DP user interface more easy and comfortable. Participants said that the background color of the OCR converted text in the newly proposed DP user interface could be change to white, similar respond was also given by participants one for color of the background. However, most of the participants were agreed on they felt more confident on newly proposed DP user interface as compare to the existing DP user interface.

For answering the second question “Which user interface you found easy to use” all participants found newly proposed DP user interface is easy to use. However, the degree was found differently which means, two users said they don’t like the color used in the newly proposed DP user interface, other than that all other participants felt easy to use newly proposed DP user interface as compare to existing DP user interface. Moreover, the difficulties faced proofreading for existing DP user interface was to concentrate on long paragraphs. Overall, participants preferred system was newly proposed DP user interface.

During the task all the participants were observed closely to find their behavior for the system use and encouraged to speak loudly if they feel something like, difficulties. While using existing DP user interface participant one said that, size of the text is very little, similarly participant seven said, difficult to concentrate, which indicate that they found, some label of difficulties using the system. Moreover, using the newly proposed DP user interface, participant one said, perfect. However, most of the participants did not say anything during the task.

Furthermore, table 1, and table 2 shows the result obtained from the SUS questionnaire where the aim of this SUS questionnaire was to check the usability of the system which check the efficiency, effectiveness and user satisfaction for the system. There is not such SUS scale difference in both prototypes but usability of newly proposed DP user interface is slightly greater than existing DP user interface which is the indication of users preference on newly proposed DP user interface.

8.1. Ethical Consideration

According to ("Lærd dissertation," 2012), while participating the users in research main five ethical principles can be applied (a)minimizing the risk of harm (b)obtaining informed consent (c)protecting anonymity and confidentiality (d) avoiding deceptive practice and (e) providing the right to withdraw. In this study all mentioned principles are

followed to make the research ethically correct and standard. For doing this research, all the participants provided the written consent form to read and orally described and sign to know their agreement for participation which was described by (Corbin & Morse, 2003). Similarly, all the participants has right to withdraw from user testing if they do not want to be which means it was informed at the beginning of the user testing if they feel uncomfortable to participate in this research they can withdraw their presence at any time during the period of data collection so, all the participants made aware that if they want to withdraw their presence they had right to withdraw from this research. Similarly, the collected data are taken, as anonymously like, participant's personal data are not being recorded to maintain confidentiality. All the data collected during data collection process anonym zed so that it is not possible to recognize the participants in the documentation. Moreover, sensitive nature of data is not collected in this study like: personal identification number similarly audio and video is not recorded so, participants are anonymously available in the study.

This research collected data through questionnaire; short interview that is stored in the computer and did not collected sensitive data like personal identification number and so on only task completion time has been recorded and noted in to the computer. Moreover, participants are asked to sign written consent form for their approval to participated on the research. Moreover, once document is finished then the collected data will be deleted from the computer aiming to maintain the confidentiality of the participants.

9.Discussion

The goal of doing this research is designing and developing the universally designed DP user interface where empirical evidence was collected through the user testing and evaluation of the prototype. Moreover, prototypes were developed in the context of the universal design means improving the usability and accessibility of the system. For developing the prototype universally designed author tried to implement key elements stated on the universal design principles and usability guidelines and principles. So, in this research related research on the topic was understood through state of art and knowledge collected through literature review is implemented on development. For doing these two prototypes were developed first one is similar to the existing DP user interface and second one is newly proposed DP user interface where in the new prototype, universally designed concepts were implemented. Moreover, this study focuses on system could be more universal design through reducing cognitive load on the system. For getting more knowledge on it, focused on related work on cognitive load and cognitive load theory, which gave some insight, how similar work has been done by researchers.

Both qualitative and quantitative nature of data has been collected in this study. For quantitative data demographic questions are prepared before starting the task and SUS questionnaire were prepared and asked to complete after finishing the task, which is post-task questionnaire. Similarly, short interview was taken which gave qualitative nature of data. All those data were collected through the user testing. To make this study inclusive, eleven participants were participated having different cultural background, age, and gender where all participants having good knowledge of using the computer and other electronic devices like smart phones. All eleven participants were university students. The reason of selecting the university going students was the use of DP portal among the people. This proofreading portal has been using among people around globe have knowledge of computer. Which means not large number of people using it. Moreover, two participants having cognitive impairment were participated in

study aiming to make the study more inclusive and participatory by involving diverse users.

For the design concept literature review was done with focused on different aspect of universal design and usability aspects by its principles and guidelines. Based on that knowledge the design concept was formulated which was implemented on development later on. Moreover, color of the text, font size is maintained according to WCAG 2.0 similarly cognitive impaired users preferred color has been implemented. Moreover, only one line OCR converted text corresponding to the original image text is available in the newly proposed prototypes aiming to make easier for the users to concentrate on proofreading easily and finding errors quickly. Moreover, appropriate design concept was created then developed prototype accordingly and that prototype was made available for the user testing.

Different evaluation methods are available and have been using in HCI research field like, heuristic evaluation, User Centered Design (UCD), user testing and so on. But in this study real users were involved in the prototype testing to make the evaluation more practical because different nature of data are collected during user testing for the evaluation and analysis where other methods may not know users opinions and feeling regarding the system. All eleven participants were asked to complete the task on both the prototypes one after another and all required information was provided to them before starting the task which means participants were familiar with the system and ready to use before starting the task.

All the participants given task the first task was check the errors on both the prototypes. Participants three said that, its really boring to check the errors in the existing DP user interface as compare to newly proposed DP user interface he added buttons are also confusing and size of the fonts are really small but in the newly proposed DP user interface felt more confident and comfortable to navigate. The overall feeling of the participants was found different but most of them found easy and comfortable with newly proposed prototype, which was also shown, in stopwatch calculation.

Overall usability of the newly proposed prototype is higher and universal design but there are many limitations on this study are discussed on limitation section.

10. Limitations of the study

Result shows that, newly developed prototype is universally designed and usable compare to the existing DP user interface by analyzing the result got in the data collection and evaluation. Reducing memory load increase the usability and universal design is the research hypothesis. The participants involved in the research were familiar with the accessing the different kinds of applications so the users who have low computer literacy may not be able to interact with the system similar way, which may obtain the result differently. Similarly, elderly and children might feel differently while performing. But the e-book portal chosen in this project “Distributed Proofreader” is platform where interested volunteer only involved so, this project exclude different kinds of disabilities. Moreover, the questionnaire used in this study is System Usability Scale (SUS) has five response options so; participants may not be able to choose appropriate scale that effect in the result. Another limitation is number of participants who were eleven so, they may not represent whole population or other users. Moreover, some people may take more time to familiar with the system and its functionality. In interview, open ended questions are asked which may evaluate the system differently as compare to other form of interview like, close questions.

Overall, there are some limitations, which may be addressed in the new coming projects but this study can provide opportunity to adopt in the real world to reduce the memory load similarly, for universal design and improve usability.

This study is not able to involve diverse users having different abilities like, visual impairment, motor impairment, and different age group. However, cognitive impaired participants were participated on the study. Furthermore, different universal design principles, usability principles were implemented but more universal design and usable system may be designed and developed. So, people with different kinds of disabilities

may not be able to use the system confidently and smoothly. Recorded time during the task may not play important role in the data analysis because the performance can be improved or altered in different tasks. However, users having learning difficulties found newly proposed prototype easy and preferred system. In second time the completion time can be improved and user might be perform better.

11. Future work

This research represents the universal design of Distributed Proofreader (DP) and studied how the system can be universally designed and becomes usable and accessible. Same issues emerged during this study, like methodology used, number of participants involvement in the study. Research may be conducted by applying another methods of evaluation like, heuristic evaluation, and others. By evaluating differently through different way, result can be obtained differently; likewise, system can be tested with more participants.

Furthermore, not all accessibility guidelines are evaluated which may be possible in future to check the accessibility aspect of the system. Like, Web Content Accessibility Guidelines (WCAG) 2.0, Authoring Tool accessibility Guidelines (ATAG) 2.0, User Agent Accessibility Guidelines (UAAG) 2.0 and many more.

Moreover, the following issue has emerged during the research and need to be studied depth in future.

1. Future development of the user interface.

User interface of the system can be developed with more functionality and various options, which makes the system easy for the users.

2. Check the compliance with the accessibility guidelines.

User interface can be evaluated with the different accessibility and usability guidelines, which makes the system more usable and accessible for the volunteers having different kinds of disabilities.

3. Number of users in the evaluation of the system.

Only eleven participants were participated in this study so, in further study more participants might be recruited having different kinds of disabilities that may be able to give more factual result.

4. Evaluation techniques

By using other evaluation techniques like, Heuristic evaluation may be applicable for this research to save the time.

12. Self Reflection

Choosing to develop and evaluate crowdsourcing application gives opportunity to check the different crowdsourcing applications and Distributed Proofreading (DP) has been chosen for this project among other web portals. Universal design and accessibility has been very important to make the system and other devices inclusive. Moreover, millions of peoples are facing different kinds of disabilities like, motor impairment, cognitive disabilities, blind, and many others these difficulties cause problem to get access with the web and other system.

Researchers have been working on how to involve those peoples in digital revolution and get access to the technological changes and access to web. In this study, the work is related towards to make the web page universally designed. Moreover, tried to redesign and developed Distributed Proofreader user interface by adding universal design concepts and also accessibility and usability issues be addressed to make the system for many users possible including some kinds of disabilities. Distributer Proofreader is a platform where Optical Character Recognition (OCR) converted images be proofread, that means interested volunteers work on the OCR converted text via Internet and make available for the final version. To convert the physical books in to electronic form, first books are scanned and those scanned copies be converted in to

editable form by using different algorithms like OCR where the users or volunteers matches the OCR converted text to the scanned images to check the errors. So, simple, easy, universally design user interface encourage many peoples to use the system and improve usability and becomes inclusive.

The aim for doing this project is to make the system universally designed, and improves its usability for involving more peoples in to the system.
Universal design principles: there are pre defined universal design principles for the system, software, hardware and many more so, these principles were studied and mentioned in document which are implemented on this prototype aim to develop universally designed system. It was not possible to implement all seven universal design principles in the system but few are implemented especially focused on decreasing memory load on the system.
Accessibility: to make the system accessible for many peoples as possible considering accessibility is important, knowledge has been gathered through Web Accessibility Initiative (WAI) and prototype is designed by considering Web Content Accessibility Guidelines (WCAG 2.0) like, for the color, font type, font size and so on.

Starting from the beginning I have faced so many difficulties like, formulating research questions and generating hypothesis. Moreover, choosing research methodology for this project also took time for me. For deciding appropriate method writer was went through related research in HCI. Literature related to the subject like, cognitive load, digitization, universal design, and accessibility helped to formulate hypothesis and gave idea to ask the research questions.
Designing and developing prototypes was the main task of the research to evaluate through the users so, prototype was designed first after getting the knowledge from literature survey then after those design concepts were transferred in to development. Because of the time constraint AXURE prototyping tool has been chosen for developing the prototypes and interactive prototypes were developed for evaluation.
Another difficulties faced while generating the questionnaires but after getting some idea from previous research done I decided to provide pre-task questionnaires and

post- task questionnaires to collect the data, which are analyzed to get the result. Similarly, choosing number of participants for the evaluation was another challenge faced but after getting concern with supervisor and other students decided to participate eleven participants where tried to involve different age groups, gender, and different abilities.

Developing universally designed prototype is the main aim of this research so, for evaluating the prototype involvement of different peoples having different kinds of disabilities is important but, only participants having cognitive impairment have been participated in this study because, first this system (Distributed Proofreader) is not only focused for special kinds of users and this user interface is evaluated with the universal design principles and some accessibility principles. So, universal design principles were implemented in the prototype and evaluated with the users. There could be other evaluation methods like, heuristic evaluation and many more but decided to evaluated through real users to get their opinion and preference on the system. So, it was challenging to chose evaluation method at the beginning but user testing has been chose to collect the data and evaluation because real user can gives better result than other methods. These collected data have been analyzed. While analyzing the data different statistical methods could be used but in this study simple analysis is done for SUS data. In future, data can be analyzed through another methods means other statistical methods can be used to analyze data to get the better result. Similarly, other evaluation methods like, heuristic method, user centered designed can be used to evaluate the prototype.

Moreover, user- centered design could be used to design the prototype, where prototype could be evaluated in different iterations and improved version could be considered as final version. Like wise, persons based evaluation could be another way of evaluation the prototype where imaginary users be created and prototype would be developed with their preference. User- centered design could be the better option for this study but it takes more time to finish the work. Because we need to evaluate the prototype time and again until get satisfied with it. Similarly, involvement of participants in each iteration creates difficulties for complete the project on time.

While answering the research questions and hypothesis, collected data are analyzed and result is presented on this document where, it was found that users get more satisfied with newly proposed universally designed prototype and preferred newly proposed prototype as compared to existing prototype, in future work, this system can be developed for real use where users can finish their task quickly, and able to find errors similarly, different kinds of users can access the system and perform task makes system usable and universally designed.

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Appendix A: System Usability Scale (SUS)

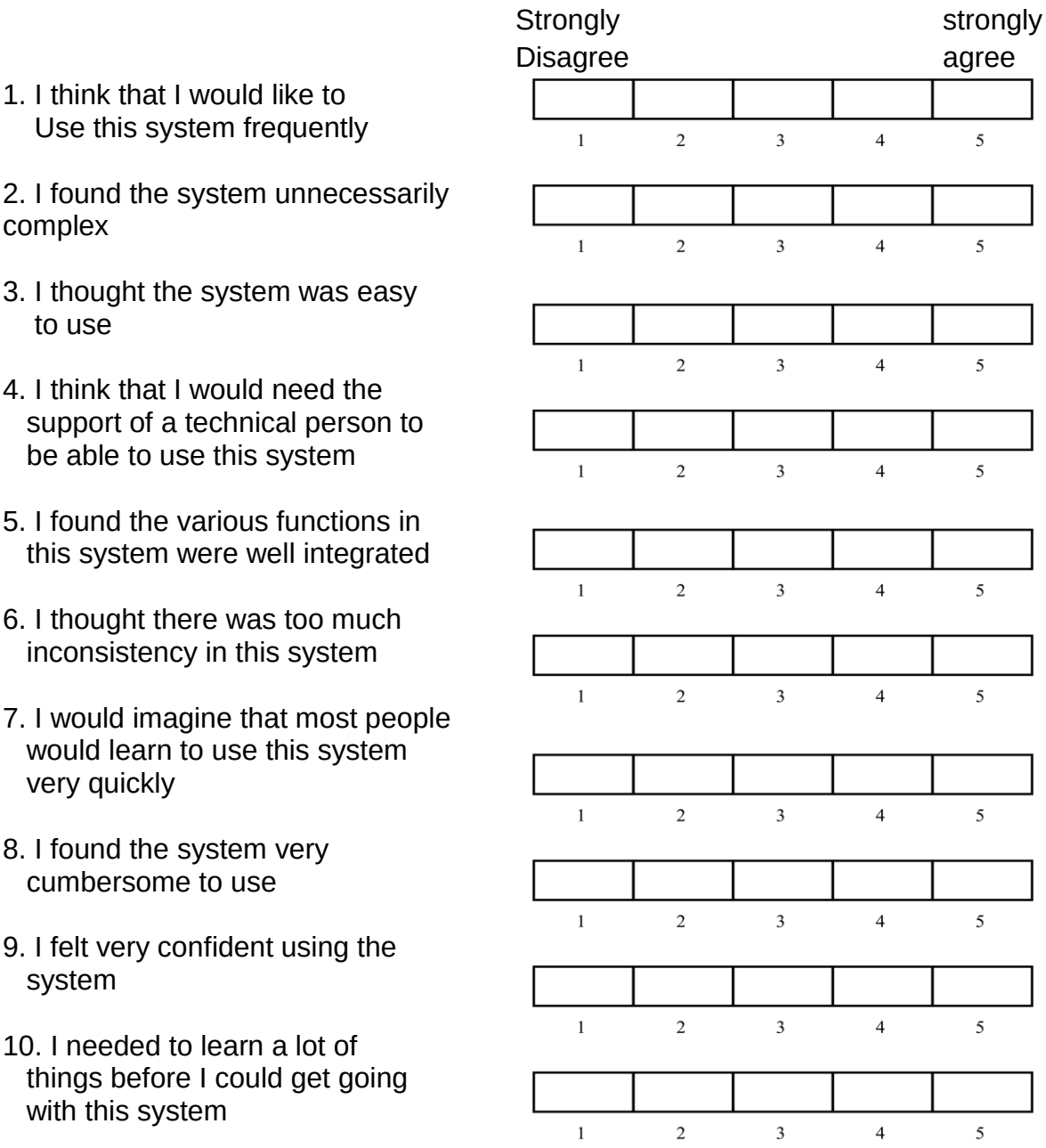

Figure A.8: SUS questionnaire

Appendix B: Consent Form

Universal Design of Crowdsourcing Application

Background

In this study Distributed Proofreader (DP) portal is chosen. Distributed proofreader is a web-based method to ease the conversion of public domain books in to e-Book. Many volunteers can work on same book to accomplish the proofreading because, it takes more time when only one or few volunteers work on it. During the proofreading, volunteers are presented with the scanned image text corresponding Optical Character Recognition (OCR) text on same page in different window where volunteer compare OCR text to original image text and proofread. The accuracy of OCR is not 100 percent so the image text should be proofread.
The aim of this research is to design the DP user interface universally designed so, volunteers can easily compare OCR text to image text, accurately, timely and navigate the page easily.

Changing physical books in to electronic form is complex task. First physical books have been converted in to electronic form through scanners or through other medium. Once these images are ready then these need to be converted in to editable form, which is possible through Optical Character Recognition (OCR). When image texts converted in to editable form then OCR converted text need to be checked with image text because each and every texts may not be converted in to editable form same as image text. This is done to make the content error free.

For this study DP portal is chosen and tried to design and develop universally designed user interface of DP and evaluate this through the participants aiming to make easier for the volunteers who involves on proofreading.

Information About Participants

Confidentiality will be maintained in this study. Personal information like, name, personal number, ethnicity will be not collected. All the collected data will be stored in the computer where nobody can get access. The participants will be not recognized in the documentation of the study. After completing thesis all the collected data will be deleted.

Voluntary Participation

The participation in this research is voluntary and you have all right to withdraw your participation at any time during user testing and after data collection without any explanation. When you said you don’t want to participate in the study all the collected data about you will be removed.

Consent to take part in the research

I understand the information about the research and willing to participate in this research

……
Participant signature and date