



Learning Management System for Differently Able Students

**A dissertation submitted for the Degree of Master of
Computer Science**

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Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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Abstract

Information and Communication Technology plays a vital role in our day-to-day life so those handicapped people also expecting an independent life like all others. However the prospective expectations within the current infrastructure not lift it to a reality. Even the opportunities were created for students with online learning but there is a gap for visually impaired students to access all its content.

What we are trying to find is an answer for the above mentioned problem. Even though the technology is providing a valuable contribution to the online education but it creates some gaps for visually impaired students. By selecting Moodle as the tool we are trying to minimize the accessibility concerns in Moodle and its content. A successful online learning platform must provide accessibility on top of functionalities available in the tool and the various education content available in the tool.

Assistive technologies and screen readers are developed to support the usage of tools like Moodle but yet those are not able to cover every single aspect. So the solution which is developed is converting the existing architecture into a form that which can be fully compatible with the current assistive technologies and screen readers.

Ceylon School for the Deaf and Blind is equipped with devices and technologies but unable to conduct ICT (Information & Communication Technology) subject even because of the difficulty on delivery of subject content to the students who participate for the subject. Research which is conducted identified that there were certain areas which need attention as far as concerning the accessibility and are covered during the implementation of the proposed new system with the aim of overcoming the gaps that the blind community face. Resulting system is satisfying the current standards which are in operation related to web accessibility, and the evidence to the success of the primary aim is evaluated during the evaluation process of the solution. Statistics of marks obtained by blind students for quizzes and assignment marks helps to critically evaluate the solution against the significance of the research. Results of the systems shows that blind students will get the similar level of accessibility like a sighted student.

Readers of this thesis are able to gain the idea of the flow of the problem to the solution and the final outcome of conducting this research project.

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From the beginning onwards my parents were pushing me to the finish mark like having the mindset that it is like their own race. That gave me the encouragement “Never let it go...”. Every single word that they told make me motivated and that leads me to become successful at the end.

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List of Abbreviations

1D	1-Dimensional
2D	2-Dimensional
3D	3-Dimensional
ADA	Americans with Disabilities Act
AJAX	Asynchronous JavaScript And XML
A/L	Advance Level
ARIA	Accessible Rich Internet Applications
AT	Assistive Technology
ATAG	Authoring Tool Accessibility Guidelines
BS	British Standard
BSI	British Standards Institution
CBT	Computer Based Training
CD-ROM	Compact Disc Read Only Memory
CMC	Computer Mediated Communication
CMS	Content Management System
CSDB	Ceylon School for the Deaf and Blind
CSS	Cascading Style Sheets
CSV	Comma Separated Values
DAISY	Digital Accessible Information System
DB	Database
DDA	Disability Discrimination Act
DFD	Data Flow Diagram
DMS	Document Management System

e-Accessibility	Electronic Accessibility
e-Inclusion	Electronic Inclusion
e-Learning	Electronic Learning
e-Services	Electronic Services
ERD	Entity Relationship Diagram
EU	European Union
EU4ALL	European Unified Approach for Accessible Lifelong Learning
GB	Giga Bytes
GHz	Giga Hertz
GNU	GNU's Not Unix
GPL	General Public License
GSM	Grams per Square Meter
GUI	Graphical User Interface
HCI	Human Computer Interaction
HMSO	Her Majesty's Stationery Office
HTML	Hyper Text Markup Language
ICF	International Classification of Functioning, Disability and Health
ICT	Information and Communication Technology
IDPF	International Digital Publishing Forum
IE	Internet Explorer
IET	Institute of Educational Technology
ILT	Information and Learning Technology
IMS	Instructional Management System

ISO	International Organization for Standardization
IT	Information Technology
JAWS	Job Access With Speech
JS	JavaScript
LCMS	Learning Content Management System
LD	Learning Disabled
LKR	Lankan Rupees
LMS	Learning Management System
LTI	Learning Tools Interoperability
LTS	Learning and Teaching Solution
MCS	Master of Computer Science
MOOC	Massive Open Online Courses
Moodle	Modular Object Oriented Dynamic Learning Environment
NFR	Non-Functional Requirements
NIE	National Institute of Education
NVDA	Non Visual Desktop Access
O/L	Ordinary Level
OOD	Object Oriented Design
OS	Operating System
OU	Open University
PC	Personal Computer
PEARL	Practical Experiments for Accessible Remote Learning
PDF	Portable Document Format
PHP	PHP: Hypertext Preprocessor

RAM	Random Access Memory
RCPCH	Royal College of Pediatrics and Children's Health
RNC	Royal National College for the Blind
ROI	Return On Investment
RSS	Rich Site Summary
RUP	Rational Unified Process
SDLC	Software/System Development Life Cycle
SeGA	Securing Greater Accessibility
SENDA	Special Educational Needs Discrimination Act
SLCB	Sri Lanka Council for the Blind
SMS	Short Message Service
SQL	Structure Query Language
SWOT	Strengths, Weaknesses Opportunities, Threats
TTB	Text To Braille
TTS	Text To Speech
UAAG	User Agent Accessibility Guidelines
UD	Universal Design
UDL	Universal Design for Learning
UI	User Interface
UID	Universal Instructional Design
UK	United Kingdom
UNICODE	Universal Code
VLE	Virtual Learning Environment
VPAT	Voluntary Product Accessibility Template

W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WBT	Web Based Training
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organization
WWW	World Wide Web
X4L	Exchange for Learning
XAMPP	Cross-Platform, Apache, mySQL, PHP and Perl
XHTML	EXtensible Hypertext Markup Language
XML	EXtensible Markup Language

Chapter 1 : Introduction

This chapter content describes the potential need of the proposed solution, the importance of implementing such a system to the target audience, what type of limitations and drawbacks exists in the current manual procedure is addresses duly. It is important to do a basic study about the environment and the users before we continue with the implementation. When selecting this as my Master of Computer Science (MCS) project the factors which make me motivated, the main objectives and aim of the project, overview of the project and the thesis, structure and content breakdown of the thesis also addressed in the below sections. Introduction section gives basic idea about the motivation and the suitability of the solution in addition to the potential need of it to the readers of this document.

1.1 Background of the Project

Conventional education system is now adapted with technology. Educational institutions are offering their programs through Virtual Learning Environments (VLE) to manage easy delivery of courseware for their students. Tools available for Electronic Learning (e-Learning) can be organized into following groups: Learning Management Systems (LMS), Learning Content Management Systems (LCMS) and Content Management Systems (CMS) [1]. As we know the current LMS have vast amount of features and functionalities for the personals who engaged with the system under normal condition and the ability to deal with the system in all possible ways. They can refer the learning content which is added by the subject teachers, can submit answers for assignments, can easily update about notifications, can participate for communications through messaging facility and can answer for online quizzes in natural way. Regardless of the physical condition students only require a device and internet connection to access those learning resources [1]. But there are ongoing researches on providing a solution for the people with disabilities as well. In social model, disability is express as “caused by the way society is organized”. Therefore it is not a fault by an individual or an inevitable consequence of their limitation. Furthermore the social model depicts disabled people as a part of an economic, environmental and cultural society [25]. Still there are no proper online learning system implementations with accessibility for such type of target groups in all possible ways. Even some implementations are available they do not have full accessibility features that differently able students required nor full assistive technology is supported. Because of e-Learning tools are usually web based tools maintaining its accessibility is compulsory. If no accessibility and usability align with those e-Learning systems, then

educational gaps will become higher so failing inclusive education and access for all cannot be avoided.

Differently able people usually called as disables which are unable to perform normal activities like others able to do. Disability may cause due to illness or injury. They lead to physical or mental disabilities. It makes difficulties to perform things like others.

When considering disability there are various types which can be identified such as Vision Problems and Blindness, Speech and Language Disorders, Hearing Problems and Deafness, etc. So there is no universally accepted solution to address the needs of students with above disabilities. Because of the time constraint I have decided to target the students group with Vision Problems.

1.2 Motivation for the Project

Especially in higher education, most education institutions are currently using e-Learning tools to provide the pedagogical resources for their students. But there is no proper demand for using e-Learning tools in school sector. Conventional education system is being adapted with new technologies and infrastructure. E-Learning emerged as a complementary mechanism to traditional classroom based teaching.

Ceylon School for the Deaf and Blind (CSDB) was established in 1912 with two students. Their main aim is to provide good solid education for the disabled students to make them compatible to the society. As the Mission they state “To provide a professionally managed service using quality trained manpower, appropriate technology and methods, to facilitate and enable those lives that have been placed in our care.” [2]. Because of the head count of visually impaired students’ is considerable, providing such a solution will be beneficial to them for their studies. Following Table 1 gives some idea about the headcount of blind student population in last 5 years catered by the CSDB.

Table 1: Count of blind students by gender from 2013 to 2017

Year	Male	Female	Total
2013	107	76	183
2014	114	83	197
2015	81	59	140
2016	68	56	124
2017	64	48	112

The CSDB website state their current manual process is like this; “Printed text books for all classes are provided by the Government Press at National Institute of Education (NIE) as for all other schools, however except some visually impaired children who might be able to read the printed text books, but the totally blind children cannot read plain text, and have to be provided with the Braille translations. The school is equipped with a Braille printing room, where the printed text books are converted to Braille format if they are not provided on time by the NIE. School mainly produces additional reading materials required for certain subjects. This is done by typing out the content required and converting to Braille format by using a software, and thereafter printing the converted Braille text, using Braille printing machines.” [2]. Some of the main drawbacks are time taken for data entry, Braille conversion and printing is high, and also accuracy is depend on the person who enters data. And the cost associated with the manual process is high. Once after the implementation of the system I would think that it will be a really good solution to overcome the current inefficiencies and barriers.

Once I understand the effort that they put to lift those innocent poor kids educational level, my ambition of developing such a system got highly increased. My current employment also related to teaching and academic field, the system which I suppose to implement will be beneficial to the local as well as international students without any hesitate. My vision is “Education is for all, even they are poor or rich, normal or with disabilities education must be free for all and it must be equal for any type of students”. Personally how may I involve to make more effective use of the computer for their curriculum increase my interest a lot.

Information and Communication Technology (ICT) plays a vital role in our day-to-day life so those handicapped people also expecting an independent life like all others. However the prospective expectations within the current infrastructure not lift it to a reality. Even the opportunities were created for students with online learning but there is a gap for visually impaired students to access all its content [3].

1.3 Current Manual Process

In a traditional learning environment all students & teachers get together in a normal classroom and conduct teaching & learning physically using the textbooks & the board. But based on the definition of e-Learning we combine technology with the traditional learning activities. Using multimedia delivering the course in an interactive manner is becoming a normal thing in classrooms. Since mid 1990s onwards offering education via distance education using Internet is dramatically increased. Instead of conducting classes in the old fashioned manner as teacher centric, now the concept is changed in to student or learner

centered mode. In general LMS play a vital role when conducting those student centric learning. There are lots of advantages and motivation made due to the usage of those systematic learning techniques on traditional classroom activities. It makes the location, time, pace independent learning. LMS tools encourage blended learning so it creates lot of advantages to all kind of people associated with it. In addition to that evaluation, progress checking made much easier. Based on the Return On Investment (ROI) many organizations are willing to take that challenge to move from traditional classroom to an online virtual learning space where the learning become much more manageable and flexible.

Engaging the current technology supported for normal students are not compatible with the students with vision problems. And as it is a potential need to make education for all without any limitation for certain learner category. So it is a challenging problem to find a suitable method to convert the existing LMS like Modular Object Oriented Dynamic Learning Environment (Moodle) to people with vision problems into a level without accessibility concerns. So it made me motivated to find a better solution to overcome those gaps. As per the requirement and the benefit that the society get I thought of implementing a LMS without any accessibility gaps for the visually impaired and blind children. As it satisfy the scope of my MSc project and the hunger of doing something valuable to the society based on what I learnt made me motivated more and more.

1.4 Drawbacks in the Current Manual Process

As noted current infrastructure on normal classroom based education have following set of limitations and problems. They are;

- It is Teacher centric and Students made as passive
- Less opportunities for the Students to learn by themselves
- Not centralized administration
- Not easy to evaluate students
- As all students are not equal it makes gaps between students
- Hard to give attention to all students as there are lots of students in one class
- Lack of interactivity in the class.

As our target audience is students with vision problems even using a LMS want help to overcome the issues of a normal classroom. We need to find some other tools and concepts to attach with a standard LMS. It encourage me to do a study on how people with vision problem do their learning and how can I made available those in a LMS. Those factors lead

my interest on developing such a platform to visually impaired students. Even there are existing LMS tools available targeting sighted students which are not been tailored to the specific needs of visually impaired students. It affects the quality of life of differently able students because they are not able to find proper employment. There is a lack of knowledge and understanding of disability by teaching staff as well. That also leads to create gaps between sighted students and visually impaired students. Not only that there are some misalignment of guidelines necessary for developing accessible teaching and learning material for blind students.

The main limitation in standard LMS over blind students is the gap of delivery of course content to those students. Current infrastructure has limitations to make the content available for the students with vision problems. One of the main problem is accessibility issues over current infrastructure. So my research is to find a suitable method to deliver the content to those students where they also can use the same content as normal students for their learning. There are lots of ongoing researches and discussions on this topic but up to now there is no world accepted method to implement such platform for those students.

Even Moodle support accessibility up to some extent, it is not supported accessibility in all possible ways. Though it has some gaps related to accessibility. As an example navigating through Moodle site, understanding image based content are some major issues. Because of the time, technical or cost constraints only limited level of accessibility can be achieved. If the authoring tool is not accessible it is not worthy to consider the accessibility of the resources or content available on it. Users with disabilities use Assistive Technology (AT) to access computers and Internet. It helps them to read some content/resource, send an email, perform some action under the Operating System (OS), etc. There are different ATs for different set of disabilities. Yet those technologies won't be enough to provide accessibility in all forms for people with vision problems [1]. Materials are not designed to integrate with ATs, so blind students may get incomplete or inaccurate translations. As e-Learning models are commonly designed for sighted students do not incorporate considerations for students with disabilities. Sighted students able access images and interpret those but visually impaired students are not able to access those at all. People who do not have access will miss the opportunities and advantages created by information age because most of them are designed with the mind of visual interfaces. There are some barriers in ICT which are difficult to overcome. Email, Instance Chats are one of the primary tools that people use for communication but even those are neither fully accessible nor user-friendly for people with vision problems.

1.5 Objectives of the Project

The main objective of the project is to build a methodology where visually disabled persons to get the similar usage and experience as normal students without any accessibility concerns. This requires studying on how visually impaired people engage with the manual process during studying and enable those facilities under the roof of a reputed well known LMS. Then all forms of students with or without special needs can work with the same environments equally. Through that we will be able to reduce the gap of digital divide. It makes a better learning environment to feel the same experience that normal students get also by a student with special attention, need or assistance. The system which is planning to develop will cut-off some additional cost associated when conducting training for visually impaired students using existing technology and infrastructure. Then they can get the same opportunity for learning and will be able to achieve the intended learning objectives [4]. The research is which I am planning to execute will be how the context changes apply for an existing LMS to cater special needs of blind students make the learning easier by uplifting the accessibility features of the current platform using some adaptive technology [5],[6],[7]. And the study will be on one methodology of study online for sighted as well as blind students using a single tool. Using some assistive technology we can make the user friendliness of such platform much more. To assess whether the outcome satisfy the actual user requirements, feedback of sample student set after using the system will be attached to the report as an evidence. Marks gained by visually impaired students during course activities like quizzes will be included as evaluation measurements of the resulting solution.

Most of the software and e-Learning tools are designed for sighted students with high-end graphics and interactive features. But a visually impaired students face lot of problems when compared to sighted students. Learning objectives expect by a vision impaired students must be same as sighted student but learning outcomes may need to be adjusted. Blind students rely on the translations and features provided by ATs. When considering a tool we must ensure the accessibility and appropriateness [8]. When considering accessibility for visually impaired students, solution must be holistic not something just partially accepted. Notice that our study is to analyse accessibility issues of the LMS itself, without considering the user generated content upload into the LMS like for instance Portable Document Format (PDF) files, images, etc. Research evaluates the accessibility of Moodle LMS from the point of view of visually impaired people and to make necessary changes to make it accessible in all forms. It also covers making a suitable methodology to handle 2-Dimensional (2D) structures using some other alternative method.

1.6 Research Questions

Using research questions we prepare a list of questions that we seek answers. But the research questions must be worth for investigation. They must be feasible, significant, relevant, clear and precise. They must be hypothesis based on the research topic and problem. Shaping the questions based on the topic is also equally important. As the aim of the research project is to build a fully accessible LMS purpose of the project will be making a LMS which satisfy accessibility of the tool and its content for visually impaired students with the ATs support to blind and low vision students. Following are the set of reviewed and finalized research questions for the research topic LMS for visually impaired students.

- What are the issues related to IT education for visually impaired students in school curriculum in Sri Lanka?
- What are the gaps, in related to visually impaired students over sighted students in current LMS features relates to the viewpoint of accessibility matters?
- How to enable 2D structures for Braille format using Moodle infrastructure?

The above mentioned research questions are useful to know something more about the situation and the problem. Fair research questions identify the phenomenon to be studied related research topic too. It helps to eliminate unnecessary scope of the project also guide the person who is conducting the research while it completes. Whether overall objectives are covered can be ensured with the answers obtained for those research questions. If any misalignments found, person who conduct the research can take necessary actions to take the project back to the original frame.

Apart from the above mentioned research questions, conducting an in-depth literature review we can find answers for the below points as well. Because to get detail idea about the problem having a clear picture on those areas are also important.

- What existing standards, guidelines and laws are compulsory for developing LMS for visually impaired students and what are obsolete?
- Does Moodle latest major release version 3.1 support accessibility for visually impaired students in all possible forms?
- What can we do to overcome issues related ATs with Moodle infrastructure?
- What are the Alternative formats supports for visually impaired students related to education context?
- What can we do make content equal for both sighted and visually impaired students?

- What educational model support accessibility over LMS?
- How can we integrate existing Open Source tools and application related to LMS for the visually impaired students using existing tools and technologies?
- How can we report the results obtained and evaluate the research achieved if intended targets were achieved while conducting the research?
- What are the new technologies/trends that we can use to make the solution more realistic and usable?
- How to ensure after all, end result is accepted by the real users in the domain?

How to ensure that teachers' contribution is trivial and available when preparing educational content for IT subject for visually impaired students and is it accessible and is it accept Universal Design (UD) principals?

In addition to that we can find answers for: the awareness related literature under the topic, importance of research questions related to the field, areas those require further studies, whether the study fill the gaps of the research, whether similar research conducted in this area previously, whether target community is interested about the research and solution, etc.

1.7 Scope of the Project

The scope of the project is to implement some new features, extended features for a LMS to accommodate needs of Blind and Visually Impaired students and to cater for their special needs that line with accessibility concerns to work with an existing LMS tool such as Moodle which is a popular option in the industry without any inconvenience. Accessible problems become more critical when a person with vision problem try to access a website.

With the system which is planning to develop it will implement the options for the students who have problems with visibility. The target is to develop a flexible platform where blind students may use the same context like sighted students by using some other alternative accessibility mechanisms. In addition to that some new options will be available for the course content creators, subject teachers to create assignments, sample exam quizzes, etc. System will cover all possible solutions for all forms of blind students as well as blind teachers. After the implementing the systems based on the results and outcome will consider covering some other disabilities as well including Deaf, Autism and Learning Disabilities.

Ultimate aim of the research is to reduce the gap of inconvenience, uncomfortable feeling that the visually impaired students face. Rather than having two separate systems for sighted and visually impaired students this will lead to develop a tool where all sort of students can use.

When we design something good for disable people means it is a good design for all sort of students [5]. Addressing the needs of differently able students often benefits all students regardless of sighted or visually impaired [25]. When it comes for accessibility we need to consider two things. First accessibility features of the e-Learning tool, the authoring tool. Secondly we need to consider the accessibility of the content resources available as web pages. If the authoring tool is having some gaps related to accessibility then no point of adjusting the issues related to the content [1]. First to check the sustainability Information Technology (IT) subject related course content will be enabled ensure the successfulness of the tool which is made as compatible with accessibility issues. As ATs are not capable of handling and recognizing 2D structures like images, charts, symbols, videos, etc. Some other alternative mechanism will be developed along with existing Moodle system to ensure all forms of accessibility. To ensure the appropriateness, Moodle tasks will be tested using Administrator user role. .

1.8 Structure of the Thesis

The following section illustrate the basic structure of this document where the reader will not be get hesitate or feel uncomfortable. Chapters namely Background, Analysis & Designing, Implementation, Evaluation, Conclusion are described briefly. Reader get clear picture on the sequencing of the below mentioned chapters. It helps to provide an understanding about how the upcoming sections of the thesis are organized.

Background

This chapter covers the background study of the problem. Completely describe the literature review of the problem includes learner analysis, research methodology used, research questions used, results gathered, research summery, critical decisions made, studying of similar solutions exists which are suitable to solve the problem, the features which are available to satisfy the needs, features which are not available/addressed needs to be newly implement in my solution are addressed in this chapter.

Analysis & Designing

This chapter covers the requirement analysis & design and lessons learnt. The requirement gathering techniques used, details of requirements gathered are included in this chapter. Description of the software development methodology chosen also described as a part of this section. A detailed analysis will be conducted and the results are then classified the requirements that identified as functional requirements, non-functional requirements, user

requirements, hardware & software for the proposed system and so on. Based on the study set of use case diagrams, class diagram will be drawn to demonstrate the core structure and functionalities of the system which is going to develop. The overall logical architectural plan will be finalized on this section. In addition to the above mentioned content details of feasibility study which is conducted are also attached to the content of this section.

Implementation

This chapter covers the details of the implementation process of the proposed system. Modifying the core modules of existing system, developing the new features which are finalized during analysis stage, explanation of code modules, development platform & programming language used and the tools used for the development are explained as the content of this chapter. As the solution is web based the method of putting the system into practical use how the training is provided to the system users are also included and discussed in this chapter.

Evaluation

This chapter covers the testing and evaluating strategy of the built system including the test plan with strategy and test data to be used. It also includes the various test cases, results obtained, explanations & actions taken if any variations discovered during testing, debugging actions taken, various evaluation methods used, verification & validation methods used in each section are thoroughly explained in this section.

Conclusion

This section covers the lessons learnt while implementing such a system, future plan to continue the project while adding some potential new features as and when they discovered, problems encountered and the action taken to solve those problems, evaluating the system with the support of a checklist to ensure all tasks are duly completed, finally getting the user acceptance by allowing some disable persons to use the system for their learning. As I remove some other disability areas due to time constraint, merging those features once they are developed based on the importance to the society are explained in this chapter. Even there is no Client associated with my project, my plan is to continue it by implementing it in Ceylon School for the Deaf and Blind website and continue the project with other parties who are interested on this area to get the real benefit.

Chapter 2 : Background

This chapter contains the detailed study which I did to understand the problem, solutions and the way of solving the problem. Before implementing a software system conducting a background study and literature review is compulsory to have a clear mind about the steps need to follow to solve an identified problem. Performing a complete research about the environment, people and the processes are equally important. After reading this chapter content the reader will be able to get a detailed understanding about the strategy of research conducted, decisions taken and the lessons learnt. Based on the results obtained after a successful research it can be continued for further based on the potential need to the society as well as for personal development. As we know there are lots of disability types among students but I selected only visually impaired and blind students, research can be carried out to study about other disabilities as well and it will lead to continue the research for my higher studies as well. Research can be used to discover something new, can use to verify something, can use to analyze relationship among various facts related to a specify study. As authors mentioned research can be expressed as “Research is a logical and systematic search for new and useful information on a particular topic.” [9]. It can also be called as discovering the truth of something hidden based on a research. The needed facts can be collected based on experience, through human beings, books, journals, nature, experiment, etc. The results of the research can be applied to solve the problems that we face in day-to-day life.

2.1 Literature Review

Writing a literature review for the conducted research is important. It summarized what you gathered during the research. It helps to represent the knowledge that you earned in a summarized form where it will become easy to abstract idea from the results obtained and it will make easier to take decisions. It helps to identify potential strengths and weaknesses in the research topic. While listing them it helps to eliminate the weaknesses and ensure we only carry the positives to the future. Using a literature review we can gain proper understanding about the subject and the significance of conducting such type of research. It gives the freedom to camper what we learnt during research after a critical evaluation based on what we gathered. Doing literature review can be modeled with the following diagram as shown in Figure 2.1.

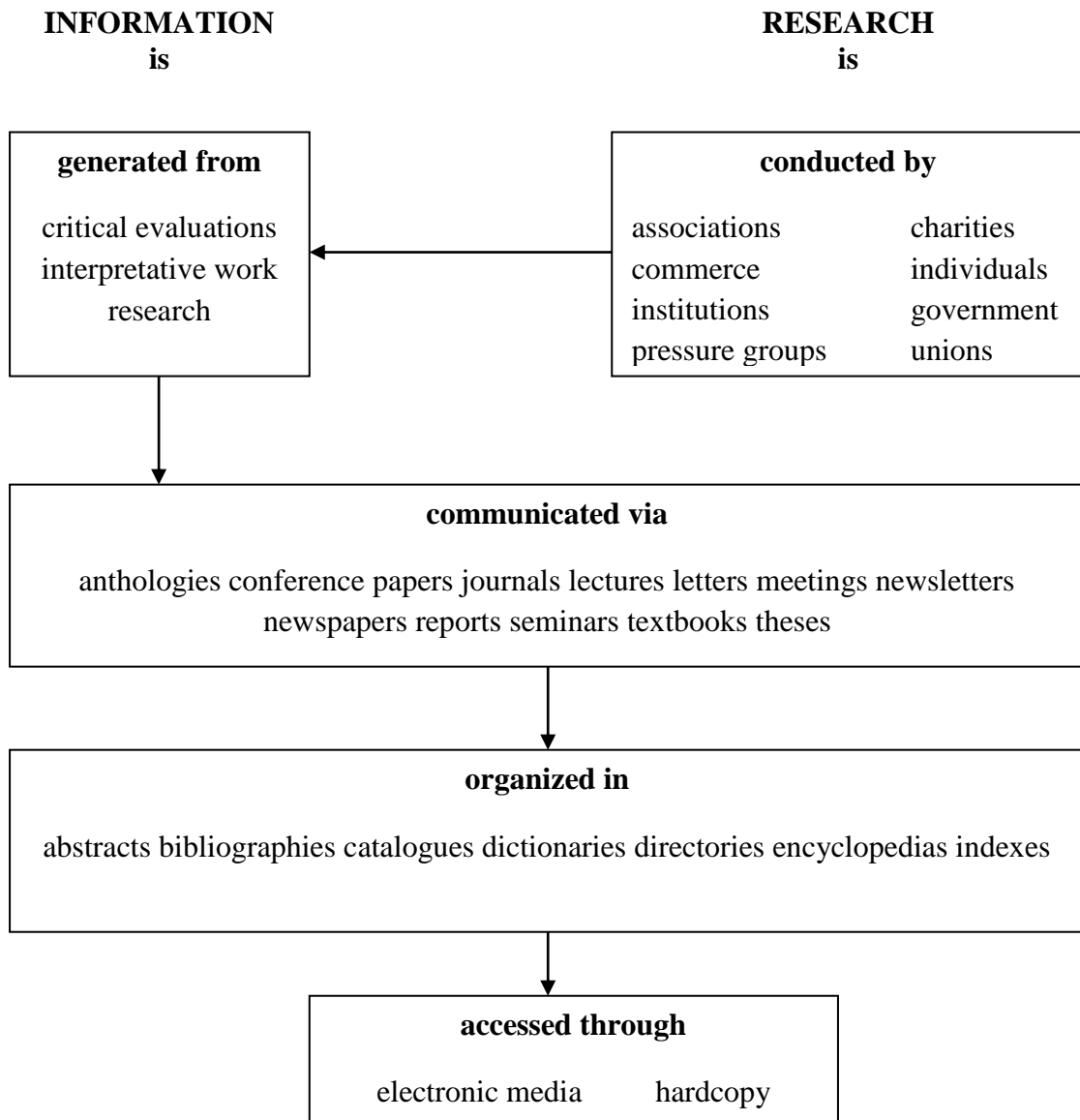


Figure 2.1 The Generation & Communication of Research Knowledge and Information

Education is vital factor for students to develop themselves as responsible adults who can put their contribution in the workforce. Therefore it is important that those with vision problems are able to gain complete education.

2.2 What is Vision and Visually Impairments

Vision is the primary sense necessary for successful learning and development. Disability with respect to education is not a personal trait, but an artifact of the relationship between the

learner and the learning environment or educational delivery [10]. Vision impaired students also require more time to complete learning tasks and assessments. As the research is focused on visually impaired students, before continue into further sections getting some idea about visual impairment is important. According to the facts of World Health Organization (WHO) visual impairment splits into two broader categories. First category is people with Low Vision and second category is Totally Blind. Low vision acuity means vision between 20/70 and 20/400 with the best possible correction, or a visual field of 20 degrees or less. A person who is Totally blind means a visual acuity worse than 20/400 with the best possible correction, or a visual field of 10 degrees or less. And people who are born blind are more towards to Totally blind category [11]. Moderate visual impairment and several visual impairments are grouped together and labeled as Low Vision. Low vision together with Blindness represents all visual impairments. Apart from that we can consider about the various types Colour Blindness as well. People may be blind since birth or have lost their sight due to illness or medication. As people who became blind after being as a sighted person have more references, memories, knowledge and experience than a person who is born blind, so they will be able to manage certain thing better than a born blind person [13]. WHO revised the definition of disability as *“The outcome or result of a complex relationship between an individual’s health condition and personal factors, and of the external factors that represent the circumstances in which the individual lives”* in International Classification of Functioning, Disability and Health (ICF) in 2001 [11],[25].

2.3 Statistics of Visually Impaired in Sri Lanka

Sri Lanka Council For The Blind founded in 1956, who is a member of the World Blind Union and Asian Blind Union is the legal governing body in Sri Lanka of the blind community. Earlier it was called the National Council for the Welfare of the Deaf and the Blind but from 1971 onwards it has been separated as two separate organizations named as Sri Lanka Council for the Blind (SLCB) targeting blind people and National Council for the Deaf targeting deaf people, and continue their service. According to their figures they have estimated that nearly 200,000 blind persons and 400,000 low vision persons are living across the country. When it comes for Sri Lankan context compared to previous years population of visually impaired persons in the community increased by nearly 10,000 based on the census conducted in year 2012. As in stand in year 2012 there are 996,939 total blind people are counted ranging from age 5 to 95. When compared to last 10 years it is a growth of 1.03%. But among them less than 14% are currently employed [16]. Services that they offer are free of charge and those are designed to improve the lives of vision impaired persons. Their vision

is “A fully inclusive Sri Lankan society in which Vision Impaired Persons can lead independent and productive lives” and their mission is to “Promote independence, equality of opportunity and full participation in every aspect of life for Persons with vision Impairment in Sri Lanka” [16].

2.4 Braille System for Blind People

Braille is a system which can be used for writing and printing by blind and visually impaired people. Louis Braille in France was the first to develop the Braille system in the 1820s. It is made up of tangible dots which are raised up from the paper that can be read by touch. There are range of Braille devices including Braille Keyboards, Braille Displays and Braille Printers. Those are required by the visually impaired people to deal with the computer. Braille printer is not able produce graphics, diagrams. It will be disadvantage for the students with vision impairments.

Braille is a system where two dots across by four dots high but mostly it uses only top 6 dots. Braille characters are formed using 6 dots and it constitutes a cell see Figure 2.2.

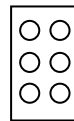


Figure 2.2 Braille Cell Format

Braille format does not support images. But basic shapes like squares, triangle, lines and etc can be formatted using Braille dots. Physically graphics can be formulated using Threads and Fabrics. In literature it highlight that there are lack of international standards for Braille code for mathematical structures.

For text representations there are no limitations because most languages have their own character set in Braille format. Using those 6 dots it is possible to produce 63 characters. Though Dot 1 have lot of meanings based on the language format that we use. As an example in a numeric pattern Dot 1 may represent number “1” whereas in English Dot 1 will be character “A” and in Sinhala it will be “අ”. Current dot 6 notation is a world standard. Usually leading Dot 6 will be used to make an Uppercase character and “..” will be used to define a block of Uppercase letters. (Eg: AND) Those 63 possibilities cover symbols like “.”, “,”, “!”, “?”, etc. Because of Sinhala language has so many characters (more than 63) it is required to use 2 Cells to represent one single character in Braille notation. For additional characters having 2 Cells is more than enough.

For standard text input we can use the QWERTY keyboard. But the specialty is they only use 9 keys from the keyboard. They are letters S, D, F, L, K, J, Spacebar, Enter, Shift keys. For Braille typing and conversion they mainly use WinBraille and Duxbury software. Like in normal typing they keep one space after each word or phrase. But there is a small disadvantage in Braille format. Braille format does not cover vowel sign. So using Braille characters it need more space, meaning more pages. It is like “අම්මආ” not “අම්මා”. So in English we need to type it as “AMMA”.

2.5 Use of Assistive Technology

For general usage they can use the normal Personal Computer (PC) with ATs but having Speakers or Headset is a must. Blind users will access the computers without Graphical User Interfaces (GUI). Having no use of GUIs blind users can be lost easily in the hyperspace. People with vision problems need tools to enable them with computers. Differently able people interact with the computers using methods other than conventional hardware, instead they use ATs. Some computer literate blind people use Digital Accessible Information System (DAISY) Player [33]. It can convert and record books content as audio. ePub is also another alternative for the similar concept [34]. Those are well-known as Comb Binding technologies. They use EXtensible Markup Language (XML) based system for authoring [25]. There are some accessibility features developed in web browsers. In Google search engine they make a noise once we focused into the search box. Apart from that there are some keyboard shortcuts available for blind users in Windows environment. They able to use Internet to find things as screen readers are available.

A Screen Readers is a software which enables people with visibility problems work with the computer system. Mainly it uses a concept called Text To Speech (TTS). It will translate information available on screen in to speech. It can facilitate the blind users by converting the text on the screen in to Speech (pronounced) or Braille output. A Braille Display can be programmed with Screen Readers so Braille Display is capable of displaying the converted onscreen text in Braille format. Screen Readers are best example for AT. But ATs can only manage 1-Dimensional (1D) structures like the natural language. Sound working knowledge and their limitations of screen readers, screen magnifiers and other ATs are important to visually impaired students in order to experience hassle free experience while using computers for their studies. Screen readers read text aloud, Screen magnifiers can enlarge the information showed in the screen, and Refreshable Braille displays convert the content to Braille format. A blind person might quite easily be able to do the task in a question with the

aid of ATs [5]. But there are some issues related to screen readers, here we discuss one main problem related to screen readers. In general table content is organized based on the columns of it, but screen readers read table content row by row [13].

Most situations NVDA (Non Visual Desktop Access) [26] and JAWS (Job Access With Speech) [27] will be used as screen reading software as they are the mostly used popular options. Out of them NVDA support both English and Sinhala language if and only if Sinhala characters are written using UNICODE (Universal Code). JAWS preliminary support English language but there is plug-in developed to support Sinhala language called “Sinhala Bashakaya”. NVDA is a free open source software whereas JAWS is a commercial software product. Current stable version of screen readers are NVDA Version 2016.3 and JAWS 17.

2.6 Accessibility Standards

When it comes to accessibility we can consider two things; first the accessibility of the platform itself then the accessibility of the content. Any system regardless of web based or not making it accessible in all sort of form is important. Especially it is far more compulsory for people with vision impairments. If the tool is not accessible at all then it is not worthy to make the content accessible. When considering about the content the content designers, instructional designers, in a school domain teachers interest of making the content accessible is quite important. Without having a clear picture on what they make and how it should be cater for the needs of blind students is challenging. It is all in a combined and interrelated as we deal with e-Learning platform and it is focused on people with certain form of visual impairment. Basic idea of e-Learning means access to online learning resources every moment and everywhere. Information available on a webpage can be properly expressed heterogeneously using text, graphics, audios, videos, etc. Unfortunately visual and multimedia interaction can be a problem for users with vision impairments [23]. It can be considered as a didactic content. With the support of an e-Learning platform students can be collaboratively work, because of students who are visually impaired readily share their knowledge so that the group achieves the learning outcomes not just as individuals. Certain level of knowledge must be considered and training need to be conducted in order to make the content accessible. It may not lead to any ambiguity or inconsistency as our plan is to provide a solid platform where all students will be equally catered during their studies. Time spent on different activities will be varying as students with vision problems may need additional time to translate and read unlike other sighted students.

As visually impaired people are fully depend on the applications those use to translate the content, people with disabilities need specific consideration and support when designing & implementing such a platform. Teachers seldom understand the needs. So tactically Teachers/Instructional designers need to be mindful about the accessibility issues, for screen readers to be able to translate content accurately. There are some misalignment of guidelines necessary for developing accessible teaching and learning martial for blind students. It must ensure the appropriateness and the accessibility alone with the usability. When considering about accessibility the tool and the content must satisfy the following Accessibility Standards and Laws [12],[19],[20],[21],[25]. W3C and Instructional Management System (IMS) supply guidelines to develop accessible website or educational resources. There are well established principals promote accessibility in software design and electronic content originated by IMS Global Learning Consortium and it is clearly addressed in IMS Access For All Overview Document.

These standards standardize guidelines for;

- WCAG - Website Content
- ATAG - Authoring Tools
- UAAG - User Agents

Following are the key factors for accessibility based on IMS [15];

- Allow for user customization
- Provide equivalent visual and auditory content and interface elements
- Provide compatibility with ATs
- Allow access for all functionalities from the keyboard alone
- Provide context and orientation information.

IMS Global Learning Consortium offered different definitions for disability and accessibility which is considering the educational point of view. They express the terms as *“The term disability has been re-defined as a mismatch between the needs of the learner and the education offered. It is therefore not a personal trait but an artifact of the relationship between the learner and the learning environment or education delivery. Accessibility, given this re-definition, is the ability of the learning environment to adjust to the needs of all learners. Accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality, and learner supports) and the*

availability of adequate alternative-but-equivalent content and activities. The needs and preferences of a user may arise from the context or environment the user is in, the tools available (e.g., mobile devices, assistive technologies such as Braille devices, voice recognition systems, or alternative keyboards, etc.), their background, or a disability in the traditional sense. Accessible systems adjust the user interface of the learning environment, locate needed resources and adjust the properties of the resources to match the needs and preferences of the user.” [15],[25].

LCMS must satisfy ATAG and WCAG guidelines both. Because in a LCMS we have both web pages as well as web content. Among them World Wide Web Consortium (W3C) plays a vital role in the community by standardizing the accessibility of web based solutions & websites under Web Accessibility Initiative (WAI) project. WAI actively giving a major contribution for the developers to improve the accessibility of World Wide Web (WWW) context for people with disabilities. WAI draft extensive guidelines when creating web pages that are accessible to many people with disabilities. WAI provide a valuable checklist for developers and educators. Researchers able use this as the foundation for further development of models, theories or tools. Even though some guidelines and laws are already in operation developer must choose which laws, guidelines and standards are appropriate for the situation and need to be considered for differently able students. Regular evaluation of standards is also highly required. As the international web standards governing body they define accessibility as *“Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web.” [12],[25].*

Table 2: Web Accessibility Standards and Laws

Standard / Law	Version / Year	Description
WAI - ARIA	1.1	Accessible Rich Internet Applications (ARIA) Suite, defines a way to make web content and web applications more accessible to people with disabilities.
ATAG	2.0	Authoring Tool Accessibility Guidelines (ATAG) explain how to make the authoring tools themselves accessible and help authors create more accessible web content, so people with disabilities will able to access content easily.
WCAG	2.0	Web Content Accessibility Guidelines (WCAG) is developed with a goal of proving a single shared standard

		for web content accessibility that meets the needs of individuals, organizations, and governments internationally.
UAAG	1.0	User Agent Accessibility Guidelines (UAAG) documents explain how to make user agents accessible to people with disabilities. Eg: Web Browsers, Screen Readers, Media Players, etc.
VPAT	-	Voluntary Product Accessibility Template (VPAT) was designed to provide information in a consistent and comparable fashion and format. It ensures product or service meet the Section 508 Standards.
Rehabilitation Act	1973	It was the first major legislative effort to secure an equal playing field for individuals with disabilities.
Section 508 Law	1998	Section 508 was enacted to eliminate barriers in information technology, open new opportunities for people with disabilities, and encourage development of technologies that will help achieve these goals.
ADA	1990	Aim of Americans with Disabilities Act (ADA) is to make sure that people with disabilities can have an equal opportunity to participate in programs, services, and activities.
Equality Act	2010	Aim of this act is to make sure that people with disabilities can have equal opportunities like others [30].
BS 8878	2010	British Standard (BS) published by the British Standards Institution (BSI) Group. And it defines a process for creating and embedding a web accessibility strategy within an organization.
SeGA	2010	Securing Greater Accessibility (SeGA) in UK is a set of guidelines developed for making online teaching and learning available for all. And its aim is to coordinate various activities can clarify responsibilities for accessibility across the institution [25],[32].
SENDA	2001	Special Educational Needs and Disability Act (SENDA) say educational institutions could face legal proceedings if they don't take into account the needs of disabled students [28].

Above Table 2 gives a list of Web Accessibility Standards and Laws which are in place. WAI-ARIA specifically aims to make dynamic web content and applications more accessible to blind people. It is focused on setting some standards and guidelines when using Asynchronous JavaScript And XML (AJAX), EXtensible Hypertext Markup Language (XHTML), JavaScript (JS) kind of web technologies [13]. Apart from the above list we must ensure the Institution/University Standards as well as State and Local Policies are also covered and take into account before making a decision that the platform is accessible. Actions and decisions can be made after a strong evaluation by considering all of the above mentioned through a checklist. But completing that checklist must not only consider as the positive feedback but also thinking pattern of the Teachers who prepare notes and content must be motivated towards the importance of thinking ahead than considering this as a solution.

Following are some other Acts related to disabled students and some of them are related to physical working environment based activities and some are related to accessibility [25]. They are;

- SENDA – 2001
- Disability Discrimination Act (DDA) – 2005 [29]

Following are some legislation which those acts place ahead educational institutions [25],[28],[29],[30]. They are;

- They must not discriminate against a disabled student on the basis of their disability
- They must make “reasonable adjustments” to meet disabled students’ needs in all aspects of their education
- They need to anticipate the needs of disabled students and not just address them on a case by case basis as they arise.

SeGA standards, guidelines are in operation since 2011 onwards and objectives of SeGA will be as follows [25],[32];

- Clarification of responsibility and accountably
- Improved access to the curriculum for disabled student
- Improved understanding of staff roles and responsibilities
- Improved documentation of reasonable adjustments
- Reduced overall cost of adjustments
- Improved organizational knowledge of enabling accessibility best practice

- Improved visibility of the levels of accessibility afforded to students.

According to the literature we can consider an accessible and usable web is a part of the concept of Electronic Accessibility (e-Accessibility) and one of the key elements in Electronic Inclusion (e-Inclusion). Its aim is to ensure that everyone without exception is included in the information society [3].

One of the main problem is that the visually impaired students may face is that they cannot read normal books available in libraries unless they are in Braille translation. So they must find a person to read those books for them. But they can refer books which are bind or stapled notes if they are produced in Braille format.

Following are the main set of elements and technologies that they used to develop the Moodle LCSM [3].

- Hyper Text Markup Language (HTML) elements
- XML
- Cascading Style Sheets (CSS)
- PHP: Hypertext Preprocessor (PHP)
- Standards;
 - o When writing headings and text
 - o When defining visual aspects.

HTML elements are used to define the structure/layout of the webpage. XML is use store and transport data. CSS is used to define the presentation and it makes to customize the look and feel of the webpage. PHP is use to define the dynamic and interactivity of the webpage. Finally standards are useful when writing headings and text content of the page and also to define the visual aspect as far as concerning the accessibility of the web pages.

2.7 Moodle Infrastructure and Current Implementations

Current releases of Moodle version 1.9 onwards laid some foundation to provide accessibility features for differently able people but yet it has not came up to the level which can handle all possible ways of accessibility in related to all forms of tasks that the tool able to perform. Like we discussed according to the literature when providing accessibility for disables it is necessary to consider the accessibility of the tool and its content. Moodle structure is organized around courses. In our case courses can be considered as different subjects available under each grade in the school. Using courses we will be able to manage the

content. They are treated as separate pages of the website. In Moodle everything begins with the layout/structure of the front page. It is the container of the content which is published under the LMS. Navigation panel, Active logged user list, Messaging facility, Important notices can be published under the front page. As we see Moodle is capable of creating and managing user roles by the site administrator. Those user roles are needed to control the way that users can work with the system. Different roles have different privileges when accessing the courseware. In Moodle, Administrators perform more complex & general tasks. Role of Student will perform limited set of tasks, while the Teachers can perform more complex tasks than Students able to do and the Administrators can execute all possible tasks. If we can ensure the accessibility for Administrator role in all possible ways then we can assure that it will automatically reflect to other user roles like Teacher, Student, etc. Students must be able to use the system without prior experience and only with a minimal training. Moodle is accessible for visually impaired people but accessibility guidelines provide by W3C, are not accomplished by the tool. And also majority of the functions of Moodle are not accessible through ATs. As my focus is to make Moodle compatible with accessibility standards and conduct the research on adding rich content to course materials without losing its accessibility.

Open University (OU) of United Kingdom (UK) is a mega university over 240,000 students with 19,000 differently able students (12%). The term Open is used because there are no education pre-requisites for enrollments. And it is one of the most leading researchers, in various aspects of accessibility [25],[31]. OU is also managing their VLE using Moodle. When considering about the UK context, Institute of Educational Technology (IET) is a key repository of expertise in accessibility and continually updates the literature on about leading research on that topic [25].

Generally students able to do Computer Based Training (CBT) by their own with the support of equipment like Compact Disc Read Only Memory (CD-ROM). It is self-paced. Whereas Web Based Training (WBT) is offered via Internet and it is collaborative. Human Computer Interaction (HCI) is a research field aiming at improving interaction of users with applications and electronic devices [13]. Primary intention of HCI is building interfaces between users and computers so it leads to increase the usability of the application. Collaborative and interactive e-Learning environments help students “learn to be”, not just watch and listen [13]. When use HCI concepts to build User Interfaces (UIs) it makes interaction more natural. According to the ISO standards interfaces should allow the user to achieve target goals in the best efficient and satisfying way [13].

The Computer Mediated Communication (CMC), methods like email which is asynchronous and chat which is synchronous, give learners the opportunity of actively participating in the learning activities through collaboration. CMC plays a vital role when building social relationships among participants in an e-Learning curve [18].

Taking into consideration collaboration can be achieved with the groupware, and it is the facility of sharing a task among multiple users. Collaboration covers larger user groups whereas Cooperation covers smaller user groups. Among collaborative features awareness is one of a key point which must be taken into account. Because different kinds of learners use many different learning styles and their own interaction practices [13].

2.8 Universal Design and Best Practices for Accessibility

Most prominently discussed approach to accessible e-Learning is using UD principals when creating learning materials. In some cases it is referred as Universal Instructional Design (UID) too. This involves designing instructional material and learning activities so they are usable by all students without the need for adaption or specialized design. Applying UD concept, the need for particular adjustments will be diminished [14]. Design quality of the materials however must not create unnecessary barriers with respect to the way that the students may interact with their computer. We already opted the factor that “Good design for disable people is good design for all”. UD is to provide content for all regardless of the learner abilities and disabilities. It has been adapted to learning by creating Universal Design for Learning (UDL) guidelines. UD support is already tailored to e-Learning tools like Moodle. When considering the content Documents with Flash Technology, Videoconferencing, PowerPoint Presentations are not supported by accessibility. All educators need not to become accessibility experts but all educators need to have an appreciation of the issues. Also avoiding the assumption of limitation is a key to success and avoids gaps. As an example some people may say as “I don’t think a blind person could possibly do this” [8]. Stakeholders’ perspectives are also equally important when developing accessible, user friendly e-Learning environments. Problems may occur due to the inaccessibility of curriculums and training materials. Not only technical aspects of accessible design but also an importance of inclusion with the learning experience makes content more accessible for visually impaired students. If inaccessibility cannot be overcome, then the gap between sighted and visually impaired people will increase, ultimately it creates digital divide between those groups.

Accessibility given the redefinition “Is the ability of the learning environment to adjust to the needs of all learners”. It is determined by the flexibility of the e-Learning system with respect to presentation, control methods, access modality and learner support. An important concept in accessibility is that of alternative presentation or equivalent activity. In order to build accessibility equivalent text description or transcription is often not appropriate. It must accept that there are fundamental limits to accessibility. It is not just a technical issue. Making adjustments to online components has also been highlighted [5]. Physical environments must be safe and accessible including appropriate computer arrangement, ergonomic devices and equipment. And it is effective if we can provide such environment for those differently able students.

This research addresses the online material accessible, pedagogical, organizational and cultural issues exist in the current e-Learning infrastructure. Ultimate expectation will be to minimize the gap between sighted students and the visually impaired students while conducting trainings on e-Learning platform like Moodle. As there are no universally accepted solutions in the literature, there is a high demand on such research topic.


The Foundation Fighting Blindness published a career book under the title “Career Information for the Blind and Visually Impaired” in order to guide the visually impaired people to find a better employment. Their target is to set some guidelines where visually impaired people may refer to plan their future. It cover all aspect related to searching for jobs, applying for them, authorize contact personals and organizational details, not only that how they must shape their education background by looking at the future is also nicely discussed under the document. So there is a great move on the society to lift the life level and benefits of those blind people. Through such programs and guidelines blind persons will able to get equal opportunities like all others. They have pointed that “This booklet is designed to address the career concerns of people who are blind, as well as those who are vision and/or hearing impaired. The purpose of this booklet is to guide you through the process of determining a career path, where to go for education and training, how to find a job, how to make changes accommodate your vision and/or hearing loss, and what to do if you lose your job. Of course, this is only meant to be a starting point. You must make your own choices and decisions based on what is best for you.” [17].

When planning, designing and developing e-Learning systems for visually impaired students, following criteria must be considered and satisfied [3].

- Planned according to existing standards like WCAG 2.0, ATAG 2.0, IMS Access For All and BS 8878
- Usability must be ensured
- Acceptance of UD
- Support for ATs.

The European Unified Approach for Accessible Lifelong Learning (EU4ALL) is a projected started to enable higher education institutions to make their teaching and learning more accessible to disabled students. Project is funded under European Commission and its approach is focused on Content Personalization for accessibility and providing a range of Electronic Services (e-Services) [25],[35]. It is based on IMS Access For All metadata specification. Furthermore EU4ALL project developed a model called 4-stage model and it is capable on evaluating the institution level of accessibility satisfaction of differently able students. Reader of this table will be able to assess their level of meeting the needs. Concept of EU4ALL modeled is summarized in the below Table 3 [25] and it is far more effective for the institutions who provide Massive Open Online Courses (MOOC).

Table 3: EU4ALL 4 Stage Model of Professionalism in Accessibility



Low level of accessibility practice (T1)	Medium level of accessibility practice (T2)	Substantial level of accessibility practice (T3)	Outstanding level of accessibility practice (T4)
<ul style="list-style-type: none"> - Responsibility and roles unclear, ambivalent - Low awareness of senior management - Low level of accessibility practice - Weak legal frameworks 	<ul style="list-style-type: none"> - Low awareness and responsibility of management, accessibility no priority - Considerable activity for SWD by single persons - Existing practice not institutionalised - Ad hoc solutions to ad hoc problems - Weak legal frameworks 	<ul style="list-style-type: none"> - Responsibility of senior management clear, accessibility a priority - CoP existing with high level of institutionalised processes - Strong legal requirements 	<ul style="list-style-type: none"> - Responsibility clear - High priority of accessibility - Institutional processes (CoP) and stakeholder involvement - Development of policies - Evaluation of implementation - Legal framework strong driver

Following Figure 2.3 demonstrate the Corn of Learning model [22].

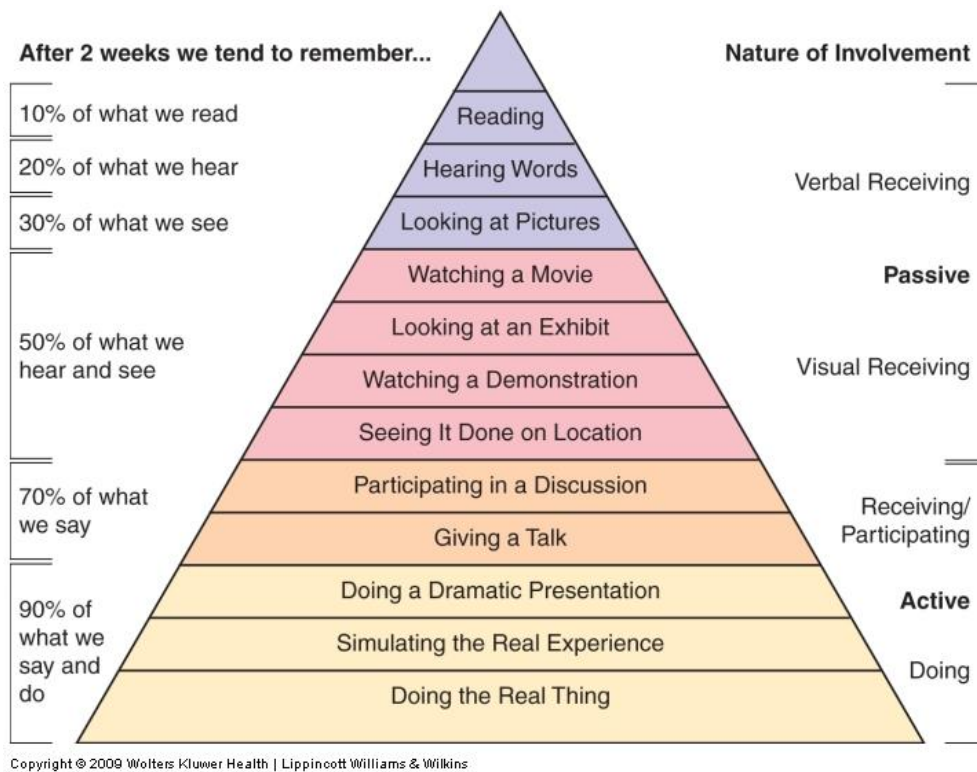


Figure 2.3 Corn of Learning Model by Edgar Dale (1969)

According to the Corn of Learning by Edgar Dale, he has stated that students who actually participate for a real learning experience remember 90% of the study that they involve even after 2 weeks. In addition to that people only remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say and 90% of what they say and do.

Indirectly it satisfies the rule of collaborative work and effective learning through blended learning. Introducing this kind of interactive learning, students will be able to understand better and remember much longer [13]. Moreover when we actively participate in learning it means we are putting our contribution and knowledge, it leads to discover new knowledge too. Using a metaphor, sight can transfer more information “in parallel”, while listening is “sequential” [24]. Meaning graphical interfaces can present overview of the content at once but audio interaction has to face with volatile human memory. Moreover when dealing with auditory information, it can be easily distracted. Problem is it makes direct impacts to for visually impaired students [13]. It is also necessary to consider the interaction of students with the environment rather than just sitting at a desk regardless of with or without disabilities. Just

making a tool online cannot achieve the collaboration unless if we plan it from the beginning. Making a web based tool compatible among cross browsers is a real challenge. In many cases rendering, visual output would be fine in Mozilla Firefox but raise majority of the concerns with Internet Explorer (IE) versions.

Following are some new paradigm of educational tools which are facilitated by the Internet [25].

- Interactive Software
- Group work in Forums or Wikis
- Use of Social Media in Peer Support
- The move to Students as the Content Creators not as the Teachers
- MOOCs
- Remote Controlled Teaching Laboratories (European Union (EU) collaborative project Practical Experiments for Accessible Remote Learning (PEARL) [36]).

When preparing documents with accessibility considering the following factors are important [25]. They are;

- Images
- Tables
- Links
- Headings
- Fonts
- Technical Format.

2.9 Challenging Problems in Existing Tools

As symbolic or graphical notations need 2D space for representation Braille code support is not available. But in certain education institutions use LaTeX to use notations in command form. It has features to produce technical and scientific documentations [37]. There are some ongoing research on LaTeX and XML support for accessibility with disables. Originally HTML is designed to present alphabetic languages in a linear fashion [25].

As discussed Alternative Formats for differently able students' benefits from the provision of education media in different formats [25]. Also "Learning Analytics" is hot topic in the field and it seeks to exploit the "big data" generated through various forms of systems including VLE for education. Nowadays computers collect vast information from every user click or

response, while they are experiencing the digital systems. Those data collected using user sessions can be used for various learner analysis tasks to provide better service and to provide learner specific customized service for all [25].

Based on the literature study conducted following set of basic topics were identified for further research related to the building a completely accessible VLE to visually impaired students. Our process begins with the research problem of checking the suitability of Moodle for visually impaired students. Before doing a basic study initial topic is more unclear and broader and now it is simplified into a set of units that smaller addressable areas to find a way of implementing accessible LMS for differently able people which satisfy the rules and guidelines of the community. So our concern is to implement a platform for visually impaired students following are the key topics which are necessitate when building research questions.

- Moodle compatibility with related to accessibility
- Sighted Vs Visually impaired learner gaps related to accessibility
- Braille support for 2D, 3D structures
- ATs and their gaps related to learning context
- Alternative formats for visually impaired students
- Solution support of Open Source community towards visually impaired students
- Support of standards, existing models towards accessibility.

Considering the above mention topics we are able to build the exact research questions as they the fundamental core units of research project. It focuses on the study and helps to build a research methodology and guides all stages of the research type of project. Below section list down the exact set of research question(s) related to the task of building a universally accepted LMS solution to visually impaired students.

2.10 Significance of Research

Conducting a properly organized research for this type of project is highly encouraged. As the project focused on developing LMS for visually impaired students there are lots of interrelated factors needs to be considered. Based on the literature study we observed that there are no universal solutions developed for this immerging problem. So conducting a significant level of research is important before begin the actual development. Research proves the feasibility of the solution planning to build to overcome the problem and the advantages for the target audience as well as for the society. Research will be helpful to analyze existing models related to building similar solutions, their concept, applicability and

drawbacks of them. It is mandatory to conduct a research before getting into actual work to make certain adjustment for making streamline the work ahead. Relevant level of research helps to clear some doubtful areas under the topic. So the author will be able to carry only the positives relevant to the subject towards project success.

Even there are LMS tools like Moodle, Blackboard, Sakai, ATutor, dotLRN, WebCT widespread among educational sector none of them are completely satisfying the accessibility requirements needed by the visually impaired students currently studying in different institutions throughout the world.

As Braille is the fundamental method for delivery in traditional classroom based training for students with vision problems having no support for multimedia context is bit challenging and difficult to overcome. So research helps to build some other alternative distribution of learning material for those students in an effective manner.

Even some guidelines are formed by the governing bodies namely W3C, IMS, International Organization for Standardization (ISO), etc. Yet there are some technical barriers which are hard to overcome by the current available technologies and support. Conducting a research also helps to gain a detailed knowledge about their proceedings and to use them when and required for adjusting existing development which is parallel to the topic.

It also useful to learn about the core structure of Moodle before customizing its code modules and discovering some knowledge to select which components or functionalities can be reused. Having some idea about overall relationship among technologies and guidelines can get better productivity and end-user satisfaction. And also Moodle is under GNU's Not Unix (GNU) General Public License (GPL) which encourages me to do a research based on Moodle as it is free to modify its core.

One of the main technical issues to resolve is how the content loads or opens. If VLE opened in particular frame and if an external link opens in another tab or a window blind users may get confused due to the different content organization structure and will not be able to identify areas with the support of screen reading applications. Standardizing the structure and layout throughout the VLE and its content is yet to be developed. So there is a huge importance of researching about those areas like content open ups, controlling navigation, etc.

Conducting a research to identify different needs and considerations of blind as well as partially blind students is significant. Because the approach of tackling needs and considerations will be differ based on the visual impairment type. As completely blind

students are fully depend on Braille system and partially blind people can get the benefit of magnification, font type changes, personalize colour customization, etc. Having a better picture on those different visual impairment types is vital when covering the all aspects of different learners.

As research leads to create new knowledge it can be used as evaluation criteria to ensure the sustainability of the solution before put it into real use. Conducting a research into a proper depth is useful when taking further decision then and there. Research can be used as a foundation to solid base where it can be further enhanced to other disabilities as well.

Because of we are dealing with a user group who are already got affected due to the introduction of ICT into education stream and the new enhancements made to the technology and equipment, having idea about their work habits, interests and also expectations will be important to get some ideas about pre-requisites which can be used to create certain checklists to ensure all aspects are covered using the upcoming solution for them. Even making the enhancements through adding additional feature will be more problematic for blind users. As they rely on ATs keeping the interfaces simple and clean is compulsory.

The study will have a direct impact with HCI as here our plan is to build a model where blind people can communicate with the computer in order to support their studies. HCI is a hot topic among researchers and the data that we gathered during user sessions can be useful for concept called big data. It is totally depends on user transactions in a domain, so here also the data gathered through each user activity will be very useful for analyzing certain work habits and patterns of users. And those statistics can be very useful for top level management in educational institutions, researchers who are interested on affairs in education sector as well as for advertisers.

Contribution of this research and literature study will be useful for the people who are planning to continue this research into new paradigm and also for people who are engaged in educational sector teaching, administration and development. And the results obtained through conducting such a research can be useful to eliminate the current gap between sighted and visually impaired students. It also allows the students with vision problems to get the equal opportunities in the society and in the workforce.

Understand the factors that make impacts for the ability to adapt with the new infrastructure and technology support by the school, encourage me to change the focus on doing the research totally on Open Source technologies available presently.

In addition to conducting research getting the help from domain experts, medical specialists are also vital. So the area of research can be fine-tuned with the comments of such professionals. It also tells whether our work is in the correct path or not. Based on that we can avoid failures and some unexpected repetitive work.

2.11 Comparison of Similar Systems

Having detail idea about the similar systems is vital to a successful project cycle. Valuable features available on them, their limitations and drawbacks can be studied thoroughly to learn some existing facts relevant to the domain. Detail awareness of those systems helps to minimize some repeat work under the same area of interest. Based on the analyze of those systems we will be able to gain some idea what functionalities cab be reused, what are the areas that we can improve and also what are the valuable points that they missed which we can consider as new potential features needs to develop. Mixing the positive features and omitting the drawbacks and potential problem of those existing systems allows good end result.

Studying only the relevant similar systems leads to isolate our work within the domain, similarly can conduct critical evaluations of the similar products. It also helps to avoid project scope creep because we finalize the features to be implemented before we begin the actual development.

Based on the initial study observed that majority of the systems are developed on top of exiting LMS tools like Moodle and Blackboard. Some of the solutions are customizations for those two and some are further enhancements made for those two without breaking its original structure. Even though there are plenty of VLE tools are available but all Moodle, Blackboard, Sakai, ATutor, dotLRN, WebCT not compatible accessibility in some cases. They are not completely satisfying the rules and laws related to accessibility related to differently able people in the domain. The main challenge faced by Learning Disabled (LD) students are to match their accessibility needs and preference in an existing LMS.

Following are the list of LMS/VLE tools which are going to be evaluated with respect to the Accessibility and are relevant to the topic of LMS for Differently Able People [3],[25],[38]-[44].

1. Task Force Project - Royal National College for the Blind (RNC)
2. Moodle Vox System - OU, UK
3. Moodle based Merlin - OU, UK

4. Moodle based Merlin - University of Zagreb
5. Yorkshire VLE
6. Canvas VLE
7. Totara LMS with Disability Matters - Royal College of Pediatrics and Children's Health (RCPCH)
8. Native Moodle
9. Native Blackboard

Based on the above list from 1 to 7 options are products and projects available in the community targeting differently able students. 8 & 9 are LMS tools which can be used as natives which we can further enhance to meet particular organization needs related to disability context.

Task Force Project is started in year 2000 by RNC focusing the special needs of visually impaired students who are aged 16 years and upwards. They initiated the research and develop Information and Learning Technology (ILT) / ICT based system for online learning for blind and visually impaired students [38]. Even the system is enable some opportunities for visually impaired students there are lots of technical issues exists in that project. What they did was while studying existing VLEs did some tailoring with the research Exchange for Learning (X4L) project, for the e-Content such as material. But it was not sufficient for the team to overcome accessibility issues.

Moodle Vox System was specially designed for educational activities for conducting collaborative learning using voice commands. It has no visual interfaces in it so interaction is made with voice commands provide through Intelligent Voice by Google. And all the interaction menus were based on Moodle principles [39]. And this solution is focused to minimize the difficulties faced by the visually impaired students to access the educational content and communication barriers. Even the system is successful up to some extend but there were commands recognizing and identification issues based on the different users speech patterns.

Moodle based Merlin is a customized version of Moodle, in OU, UK provides a VLE to their entire population of students including sighted as well as visually impaired. Their development team focuses on accessibility issues and provides those changes back to the open source Moodle community as well. There are some in house units to prepare the courseware called Module Teams and the technical accessibility is maintained by Learning and Teaching Solution (LTS) team. They prepare alternative printed materials using Comb Binding

techniques like Daisy and ePub too. As there is poor integration across units' online delivery is presently challenging. There are creating the materials according to the SeGA guidelines. OU also works accordingly to the EU4ALL 4-Stage model [25]. The effort that they put to create learning materials is costly. But yet even all those processes are in place accessibility is not 100% achieved due to lack of support and compatibility of ATs. Handling images, navigation, heading and font structure are not fully accessible for visually impaired students and still open to discuss in their system. Still there are some major revisions made to make it compliant with the students with disabilities.

Moodle based Merlin in University of Zagreb is also much similar to the above solution as it is also based on Moodle core. Same system of Merlin named as e-Students is used by the Faculty of Transport and Traffic Science, since 2004. It has 5 main modules in their system; Document Management System (DMS), Authorization and Supervision System, e-Students Module, Short Message Service (SMS) Module and Mobile Learning Module. Merlin is developed by satisfying WCAG 2.0 and e-Accessibility standards. But none the e-Accessibility recommendations were followed resulting accessibility violations. Not only that, as Moodle is an example type of authoring software ATAG standards were not even considered.

Yorkshare VLE is an accessible platform (tool). Method that it uses to create module content and share resources has some negative impacts for disabled users. And also accessibility approaches and standards are not used. These approaches often take little time to implement and improve the overall quality of resources and the learning experience [40]. But they did some work ahead to make the authoring tool accessible. But the content is not accessible. Because of that sometimes student complain saying they cannot access a particular resource.

Canvas VLE is accepted by the community as the best ever easy use LMS. It gets adopted faster and deeper than any other VLE. Users are able to turn on/off features as they want if they are not ready to go with certain features. Learning Tools Interoperability (LTI) tool support is also a major advantage of the system. LTI concept is a one of the standards publish by IMS. 99.9% uptime is guaranteed as the system is hosted on Amazon server with automatic load balancing based on the network traffic. Another advantage is its usability and architecture towards accessibility. It integrates with web services like Google Docs, Google Calendar, SMS, Facebook, Twitter and Rich Site Summary (RSS), etc. Canvas provides standard features and advanced options like learning outcomes, peer review, migration tools, e-Portfolios, screen sharing and video chat, etc. It is satisfying WCAG 2.0 and Section 508

standards. Even tool also accessible but not developed by satisfying ATAG 2.0 standards [41],[46],[47]. And the solution is originally commercial and only you can try it free for two weeks. But newly released open source version is available for developers who are interested on continuing the work.

Totara LMS with Disability Matters by Royal College of Pediatrics and Children's Health (RCPCH) is an innovative suite of free resources to support those who work, volunteer or engage with disabled children and young people, developed in 2015. It consists of Learning Packages matches the needs of various people. It is a flexible and customizable platform around the users experience and content strategy. It guarantees all users could access the same content throughout the site. Accessibility is maintained by front page customization from the user feedback from a set of questions asked at the beginning. It functionality is organized around LMS functionality involving audiences, courses, learning plans, and programmes [42]. Project also accredited by RCPCH 2015 Award for Creativity and Innovation. It is only limited to certain areas like Automobile and the course content is created by the development team itself. So the solution is limited to portion of all learners (Course related) and it is a disadvantage of the systems. And also the system is built without considering the world standards of accessibility.

2.12 Moodle Vs Blackboard

All the tools and systems that we discussed above are mostly based on the following two main LMS tools in the industry. They are Moodle and Blackboard. Next we will be going to evaluate the feature supported by both platforms. Factors we are going to consider are support for standards related to accessibility, feature support and cost of implementing. Both are having specific advantages and disadvantages related to its implementation structure.

Moodle is under GNU GPL and it is free to use and modify. But Blackboard license fee is depending on the expected number of users in the system (no. of users going to use the system). Obviously as Blackboard is a commercial product the list of features available will be more than the Moodle environment. But we can develop our own modules for Moodle as its license does not block such type of work. But in Blackboard making a change will cost you again. But in some cases it may be other way also. To find a person to modify Moodle code may be costly depending on the work that we are planning to do. Even for a small work sometimes we may require to pay a high charge based on the experience of the developer. Following Table 4 provide a comparison of list of features supported by both platforms.

Table 4: Moodle Vs Blackboard Feature List

Moodle	Blackboard
Grade management	Custom branding, fields and functionality
Student roster / attendance management	Exam engine
Assessment implementation	Multiple delivery formats
Discussion forums	Administrative reporting
Lesson planner	Course catalog
Collaboration management	Data import/export
File exchange	Grading
Internal messaging, live chat, wikis	Individual plans
	Student portal
	Goal setting
	Skills tracking

As literature recommends if a company needs powerful features then Blackboard is the option. If you plan for economic option then Moodle is ideal. Because Blackboard is known as a commercial product and Moodle is a free open source product under GNU GPL license. Having large community also makes to the life of a Moodle user easier. When considering modifications for Blackboard it always needs come through one party. When considering Moodle features/plugin we need to develop them by our own. But managing content in Moodle is much easier than Blackboard, because in Blackboard we need to do the settings manually each time once a new content is added. When it comes for help and support, Moodle is not support for online help but Blackboard has live chat facility. It is useful when building help and support. Moodle currently working ahead with approaching WCAG 2.0 requirements but ATAG 2.0, ARIA 1.0 guidelines are partially accepted by the new versions of Moodle. Blackboard also satisfies the internationally recognized WCAG 2.0 guidelines with level AA as well as the Section 508 standards [46]. But nevertheless first accepting ATAG 2.0 is compulsory as without making the tool accessibility error free making the content accessible is worthless.

As per my belief making something valuable to the open source community is much appreciated. Because education is free for all. Even the tools and technologies supported also need to be the same. As our target audience is a set of people who are far behind the normal students, allowing them to work and collaborate like all others is important. As my plan is to

donate what I implement for the Blind students in CSDB going ahead with free economic open source tools are more suitable.

Among the study of similar systems we got to know that there are no broadly accepted solutions for the problem. So after doing a research lessons learnt is useful for adding the highly important features to an existing widely use LMS is confirmed.

2.13 Selected Mixed Mode Approach

After conducting the detailed study of the problem following decision is made. As we know there are various types of research methods/approaches are available, among them there are some variations which may lead to address and validate the lessons learnt upfront. So the method which is selected will move the solution to the problem towards success that we are trying to overcome. It tells the method of finding information for our research. It is more towards how data is collected, how it is analyzed and how data are interpreted. It spans the big process into smaller steps.

In our case combination of both Quantitative research and Qualitative research will be used as some cases the data which is collected for analyzing is numerical/statistical and some data which is collected are related to human behavior and experiences which cannot be analyzed statistically. So it can be expressed as a mixed approach of those two general methods.

Having conducting the Mixed Mode approach, it allows conducting the study based on multiple methods. It is very useful when shaping the decisions that we make during research. Therefore depending on the situation we will be able to use any method as the researcher will get more freedom when doing certain things. So the limitations which exist in each method can be overcome using other method. Because one method will not be enough to provide answers for all of the problems that we face during analysis. So it is best suited switching between approaches when we are unable to find an answer for a problem. Quantitative research helps to develop some hypotheses so we can call it as a deductive approach. Whereas Qualitative research is like the opposite of Quantitative research so it is based on inductive approach.

We must have some relationship among the method that we select and how we conduct the analysis. In order to find out the best solution to any given problem those two must be consistent with each other.

Chapter 3 : Analysis and Design

This chapter content covers the requirement analysis & design phase of the research project and the lessons learnt through the activities of the analysis & design process. Following sections describe the requirement gathering techniques used and the details of requirements gathered. Section also categorizes the requirements which are identified into Functional requirements, Non-Functional requirements and Software & Hardware requirements. List of identified systems users are also included to get idea on each and every user requirement against the main problem. Description of the software development methodology chosen also described as a part of this section. The overall logical architecture of the proposed solution will be included in the below section along with a set of use case diagrams, class diagram, etc. It helps the reader of this thesis to gain some idea easily about the core structure and functionalities of the system which is planning develop. In addition to the above mentioned content complete database structure and the relationship among the tables are also attached to the content of this section.

Information which are collected during research is examined in this chapter and the broader problem is break into smaller addressable components which can be easily understood and managed. It can be used to model the relationship among those units. The term system decomposition is what we conduct during this phase. In addition to that how newly proposed solution matched to the problems exists are also discussed in this section. Feasibility of the proposed solution is also evaluated parallel to the process.

Content of this chapter is separated into two main sections. First part of the chapter covers the activities and the processes of the System Analysis phase and the other half organized its content to demonstrate the System Design phase and activities.

3.1 An Analysis of the Problem

Before suggesting new things we must study about the existing system to identify what exactly the problems are. That detail study helps to overcome the problems which are exists in the current process. The term System Analysis refers to identify the problems and to fix them in a productive manner. It can also express as a process of observing which is compulsory for problem solving. Study which is conducted will be useful for achieving system goals and objectives. Simply it says what the system is desired to do in most efficient manner. The term System can be identified as collection of components grouped to perform a specific task.

3.1.1 Information Collected from Requirement Gathering

In order to collect data/information we can use one of the following requirement gathering techniques. Some of them are Interviewing, Questionnaires, Observation, Focus Groups, Brainstorming, Prototyping, Document Analysis, etc. Among them for our work, following set of techniques has been used.

Conducted an Unstructured Interview by asking some general questions to get some basic idea on how people work in the school. As it is not enough to gain enough knowledge about the actual problems that they face some deeper level of information gathering is made based on Focus Groups and Brainstorming. To conduct those some sample audience selected based on the Observation which is done based on initial site visits. First initial Interview conducted involving School Principal, one Administrative Staff Member and School IT Teacher in charge. Based on the work and the responsibilities which undertake by IT teacher in charge further discussion is carried out to form some audience to carry on the Focus Groups and Brainstorming based requirement gathering. Parallel to that (Strengths, Weaknesses Opportunities, Threats) SWOT Analysis is conducted to identify internal and external factors which are important to achieve objectives of the proposed solution. Among them Strengths and Weaknesses are related to the organization internally then Opportunities and Threats are related to the organization externally.

We can interact with the users by watching them how they involve/contribute to the work processes and also by talking to them to explore their needs and expectations from the proposed system. It is very successful as people may not tell everything and sometimes they are not able to explain what they really want. By using Observation we can see how users work in the domain and using that each user contribution can be carefully analyzed. It can use to study each user responsibilities and their role in the domain. Users and their relationship, communication among users can be identified easily without disturbing to them. They will not be uncomfortable or unhappy as their role on the domain will be studied by watching them how they really work. But it is difficult to take decision based on how they work still it will be useful when identifying actual user requirements.

Following are the information gathered during analysis. Students in blind school study same syllabus curriculum for all subjects like other normal government school students but except for Mathematics subject. As in that no Geometry section is included because like we discussed earlier in Braille system there is a limitation of representing 2D structures and graphics.

Earlier NIE Maharagama government press publishes and manages all Braille textbooks for each subject for all grades. But now it is managed by Rathna Prakashana at the NIE premises. If any delay of getting books school is able to produce the books until they get the required stocks. When additional reading books or study materials required, they are produced in-house by printing department in the school. During examinations time when exam papers released by the Government Zonal Educational Office are converted into Braille format and students of the school sit for the exams on the same day like other school students. For government examinations blind students get more time than normal students. Blind students use 2 different methods when answering for question papers. They use either Slate and Stylus or Braille Typewriter. Among them Slate and Stylus is slow and painful method, but Braille Typewriter is much faster and easy to access compared to the other method. As writers are function based on user button presses, it can easily get damaged based on user errors or bad usage patterns/habits. But slate is more towards hard use. Students with vision problems usually get additional 10 or 20 minutes for every one hour than other normal students. Partially blind students Read Normal Text and provide Braille Answering. Totally blind students perform Braille Reading and Answering. During government exams if a student wishes to sit for exam under blind category they must sit for all subjects in Braille method.

School has a fully equipped computer lab including Braille keyboards and Screen reading software which can read both English & Sinhala characters.

In present situation they are not offering Ordinary Level (O/L) ICT subject in school as there is a less demand for the O/L ICT subject among students in the school. Only 3 students did O/L ICT in 2012/2013 years. For Computer subject they only teach;

- Keyboard Orientation (mostly)
- Computer Basics
- Office Package (only Word, Excel and PowerPoint)
- Internet Basics

They think computer education is more useful for students who completed their Advance Level (A/L) examinations rather than O/L examinations. None of the other subjects use computers while learning except for Western Music subject they use Internet in some cases but that also very rarely.

When comes to Braille printing to print one page single side it costs Lankan Rupees (LKR) 10.00 and for double side printing it costs LKR 20.00 including the paper cost. When

producing handouts they use 120 Grams per Square Meter (GSM) to 180 GSM papers and for books they use 150 GSM papers. Even both sides Braille printing will not cause any difficulties for the readers.

Even though images are by default not supported in Braille system, but squares, triangles, lines with basic shapes can be formed using Braille dots. As other graphics supported with Threads and Fabrics, for History subject they use Maps build with threads and fabrics. In Science Lab they have modeled the Heart, Eye, Liver and Bladder using fabrics.

Students who sits for O/L Science exam face for a small problem as diagrams are on the paper is not supported by Braille printers so images on the paper is not understood by blind students.

School is funded with 3 Braille printers and all of them belong to the Everest Model. They are very complex printers and controlled with a Motherboard and Hammers on it. As no language limitations for Braille characters every language has their own character set in Braille notation.

When working with computers in the lab having speakers or headset is a must as students required to work with screen readers. Even though some Text To Braille (TTB) converters are available there are only few Voice to Braille converters are available in the market. But all of them are commercial products. Dragon is one of the most popular option, but it is also a commercial product. In local context a person called Mr. Dilum Chaminda a Software Engineer works for Jinasena Group developed Trilingual Dilum Braille Convertor in 2012 which can convert English, Sinhala, Tamil UNICODE based text in to Braille text in one go. No health issues or accidental damages cause by using computer by the blind students because prior training and awareness is given by the teachers in advance. But there is a small chance of losing data due to blindness because of accidental deletions. Still those chances are also minimized because blind people are more careful than others. They put full attention than others when doing their work/learning. Students are using computers not for education curriculums but for entertainment in most situations. They are more interested on listing music, searching songs, etc.

As blind users cannot read normal books in a library they need to find a person to read books for them. Still they can use Internet to find information with the support of screen readers available.

For school work Slate and Stylus is provided by the school free of charge. But for government examinations students are required buy a personal answer writing method by their own.

During the discussion it was opted that there is a high demand for Law field among blind students. Also Wijeya Newspapers Ltd. Introduced a Braille Newspaper for the blind community to make a difference in their lives in late 2011.

Based on the discussion also it highlighted that even though the interest is there by blind students to use the computer for their studies, due to lack of tools and support by the community they are only stick to the basics and afraid to break the limits.

3.1.2 Functional Requirements

In general functional requirements are functions or functionalities of the system. It tells what the system is supposed to do. It can also be called as desired outcomes of a software. Usually functional requirements can be expressed as components/parts of the system and it is aiming to cater for certain problems or user requirements. Functional requirements can be derived from analyzing the problem and user needs. It describes the behavior of a function, what the inputs to a specific task are, what sort of processing is done to achieve its objectives and what the outputs of that function are and so on.

Following are the set of Functional Requirements which are identified during analysis. They are;

- Provide easy navigation throughout the Moodle LMS
- Provide facility to represent tables and its data contents in an understandable manner
- Provide facility to represent 2D structures for blind users
- Change core of the Moodle system to support multiple quiz/assessment durations for different student types
- Making all Moodle functionalities fully accessible according to the accessibility standards
- Giving alternative formats to access content by blind users
- Provide customize facility for user interface by the viewer
- Provide shortcuts to access functionalities
- Catering Course Content for ICT subject which is align with ATs and screen readers which are fully accessible.

3.1.3 Non-Functional Requirements

In general Non-Functional Requirements (NFR) addresses the system quality attributes or quality characteristics. It tells how the system must behave. It can also be called as a description of how the system is expected to work. Usually non-functional requirements can be used to judge functional requirements of the system and it is aiming to check whether functional requirements can be achieved in a satisfactory level (quality). It describes the method to perform a specific function of a system while maintaining its quality of work.

Following are the set of Non-Functional Requirements which are identified during analysis which must be maintained by the proposed solution. They are;

- Accessibility
- Availability
- Consistency
- Reliability
- Usability
- Performance
- Efficiency & Effectiveness.
- Platform Compatibility
- Maintainability
- Robustness
- Response Time
- Safety
- Privacy & Security

3.1.4 Software and Hardware Requirements

In order to run software there are certain hardware are required. In addition to that in software development projects there are various software required for both project development as well for implementation environment. Those are known as system requirements. This section separates those requirements into software requirements and hardware requirements. For clear separation it has further classified those requirements as Development Environment and Implementation Environment. Those system requirements are;

Development Environment

Software Requirements:

For developments Cross-Platform, Apache, mySQL, PHP and Perl (XAMPP) version 5.6.3 is used alone with Apache 2.4.10, PHP 5.6.3, mySQL 5.6.21 and phpMyAdmin 4.2.11 on top of Microsoft Windows 7 64bit OS.

To use and customize the Moodle code base Moodle 3.3.2 is used. For writing program coding notepad++ 6.9.2 is used.

Hardware Requirements:

Intel Core i5 2.7 Giga Hertz (GHz) based system with 4 Giga Bytes (GB) of (Random Access Memory) RAM and 10GB free Hard Disk space.

Implementation Environment

iPage shared hosting plan for hosting the content and a sub domain from the following domain <http://www.csdeafblind.lk/>. For the VLE portal which is going to implement for the blind school students we are planning to use the following sub domain <http://vle.csdeafblind.lk/>.

Hardware and software are depending on the plan that is offered by the selected hosting plan.

3.1.5 Users of the System

Users are the people who will use the final product to perform a specific task or a goal. These days users become a very important segment in the process. The people who manage other users also have certain expectations too.

To achieve a usable and acceptable system all primary, secondary and tertiary users and their requirements must be carefully identify. Users say what they wanted by the system not what the organization required. Following are the system users which are discovered during analysis and are highlighted in Table 5.

Table 5: System Users List

Primary Users	Secondary Users	Tertiary Users
Blind Students	Section Heads	Principal
Subject Teachers	Vice Principal	Project Coordinator
ICT Subject In Charge	Developer	

3.1.6 System Constraints

Main concern about the Moodle LMS is as the main interface is containing lots of components on it, then it will be difficult for the blind users to work around with. Even screen readers are available then it will mix the content and the person who access the system will not be able to get a clear picture on what it is organized in the screen even it is accessible. So

Moodle interface and content arrangement is a constraint for easy access. So some of the main features are only can be presented on the main interface.

As blind users usually take more time to accomplish a task, then Internet connection will be idle during busy periods such as during online assessments, participating for lecture during school time, etc. So having a good Internet connection is important. It can also be considered as a constraint to the system.

In order to make Moodle system fully accessible to blind users most of its sections needs to be readjusted with “*accesskey*” option given with HTML to make components accessible using shortcuts through the keyboard. It makes time as a constraint and also in some cases database size will be increased based on the changes that we make to core structure of Moodle. System which is planning to develop is constrained with the time and the capacity of the database as well.

Finally the screen side constraint of mobile/hand held devices also a constraint to the system. Even every element will be available on the mobile screen, navigation and accessibility will be difficult using small screen sizes.

3.1.7 Assumptions and Dependencies

One assumption that is made is system is accessed using Mozilla Firefox browser to get same experience by all the users. And same set of screen readers, ATs are used by every VLE accessing device. Because there are some variation among browsers and screen readers to get the same use and experience it is advisable to use same environment.

One simple situation where different procedure is using is, when accessing keyboard shortcuts to trigger “*accesskey*” is different among major web browsers.

And also we assume that everyone will access the VLE during lab sessions only to strict into same tools and technologies.

3.2 Selected Approach/Methodology for System Development

When considering software development projects selecting a suitable approach for system development is bit challenging. As each method has its own pros and cons. Before selecting and approach we have to look in to the phases of Software/System Development Life Cycle (SDLC). In general SDLC is a linear structured method where completion of each phase it carry forward what it earned in the previous stage to the next stage. The process runs through

initial investigation, analysis, designing, implementation and maintenance stages. Selected approach for system development will create a basic framework to follow during the project.

Even though the Waterfall model is the oldest method which has the main drawback of required to stay until to the end to test and put the system into use, still it is used by many projects along with the other new process models. For my research project Waterfall model, Prototyping and Rational Unified Process (RUP) will be used together as the selected approach when developing the project.

As Waterfall model consist of clearly defined process stages it is easy to identify all potential requirements in early stages of the development. Not only that, it is very useful method to identify problem upfront. With that we can keep the scope fixed rather than extending or reducing its scope. Having finalize those requirements in early stages of the project, developer will get the opportunity to strict into the initial time plan set during analysis, resulting less problems when it comes to later part of the project. But as it has a big impact on delivery everything at last because of the linear fashioned framework, we may require to look into other options like Prototyping, RUP and etc.

As Prototyping is based on some iterative cycles after discovering the requirements through initial investigations, it is far more suitable for our case as we can break the problem into more understandable, manageable components. Not only that this method will increase the level of user participation and continuous feedback which can be used to make necessary adjustments to the requirements and design of the system to make it more acceptable by the end users of the system. And the waiting time to experience the real system can be minimized, resulting high chances of making the system accepted. Because we can resolve certain unclear objectives of the proposed solution through validating the user requirements based on the rapid feedback that they provide in each iterative cycle. But there are some negatives of this process as well. One main problem is there is a high chance of requirements getting change. It would be mainly affected to the time plan and the scope of the project. Sometimes it may lead to scope creep too. Another major issue is we will lose the chance of controlling the project in a proper way.

As RUP is based on the concept of reusable component analysis, it is far more closer option for a project like this. It also in the nature of iterative fashioned development nature. As we are working on the Moodle core and look into modifying its core to make it align with accessibility for disables and as the Moodle platform is based on web architecture, RUP will be the best approach of achieving the project goals. It is suitable for catering dynamic

requirements of the system users. Having mixed those approaches together we can achieve a sustainable product which can guide us to achieve the primary targets of the proposed system.

3.3 Selected Design Techniques

During system design we develop the overall logical architecture of the proposed system. It mainly covers the algorithmic way of solving the problem, UI designs, database design, process design, etc. Because we cannot just start the development without having a detailed plan of how we can achieve our objectives. It describes the process of achieving objectives in a systematic manner on how the customer needs are met.

Software Design is also an iterative process. We cannot obtain the final design in one go. Design solution must be realistic, as it must be able to convert into a working program. First version of the design will be an Informal Design, based on the revisions made we can achieve the final Formal version of the design.

First the system architecture must be designed. For that we must clearly identify the system and its sub-system components, their relationships, etc. Then each sub-system component must be addressed separately. After that process design of those sub-system components can be done separately.

When selecting design technique we must consider the system design methodologies available to build the system architecture. In general we have Structured Design and Object Oriented Design (OOD) which can be used to develop the algorithmic solution.

As the industry use RUP as one of the system development methodology, when designing the system my plan is to work with OOD. RUP is suitable when there is some risk associated with the projects. First stage Use cases can be used to identify the potential functions of the proposed system and the work will be expanded based on the objects related to the Class Diagrams.

For the new data items and the tables introduced to model the architecture of them several Entity Relationship Diagrams (ERD) will be drawn to see the relationships among those new data items and the existing ones.

To get some clear idea on how complex functions work draw some Flow Charts or Data Flow Diagrams (DFD) when required. But in order to keep focus on research nature rather than development based project only included the most important diagrams in order to gain the enough understanding about the system design which is carried.

Because of structured methodology is organized around functions, will use combination of both structured designing principles as well as OOD techniques to cover the system design in an acceptable understandable manner. But main aim would be conduct design based on the concept of Objects and their relationships. Following section gives some idea on how the sections are organized to cover the system designing process, its activities and the system design.

When considering the accessibility UI structure will be changed in this manner. All form elements, navigation links are formatted with “accesskey” property. Following code blocks gives a brief idea on how “accesskey” is embedded into the existing Moodle Login related sections. In similar fashion other relevant functionalities will be changed to make basic level of accessibility by the platform. Additional measures taken to improve accessibility for blind students will be discussed in detailed manner in the Implementation Chapter.

Login URL

```
<a href="http://vle.csdeafblind.lk/login/index.php" accesskey="l"  
id="yui_3_17_2_1_1507905141084_155">Log in</a>
```

To make the Login hyperlink accessible by blind users’ simple letter “L” (“l”) is used. In Mozilla Firefox we can use the keystrokes, Alt + Shift + “l” to trigger the focusing to the “Log in” link and then “Enter” key can be pressed to navigate to the login page.

Login Page Form

```
<input name="username" id="username" size="15" value="" type="text" accesskey="u">
```

```
<input name="password" id="password" size="15" value="" autocomplete="off"  
type="password" accesskey="p">
```

```
<input name="rememberusername" id="rememberusername" value="1" type="checkbox"  
accesskey="r">
```

```
<input id="loginbtn" value="Log in" type="submit" accesskey="l">
```

Same as the above navigation link to make the Login page form content accessible by blind users’ related characters are used. It is highly important to use specific character as label tags are read by screen readers so the character which is use to trigger the shortcut access must be compatible with the label identifier specified and read by the screen reader.

3.4 The Structure of System Design

Structure of the system design organized around several main sections. As the system design is helpful to identify the overall picture of the system which is planned to develop before the actual development begins. It covers the all aspects of the solution to the identified problems. It guides the developer to achieve system objectives. Following sections include the procedure and details of how the design process is conducted and what techniques it has been used for system design. Process is divided into several sections namely architectural design, process design, UI design and database design. As the documentation of this research project required including only the major design principles and techniques used, it only consists of only the major design work performed during system designing.

Following sections include the overall technical architecture of the system. How the processes are breakdown into smaller segments, certain set of OOD design diagrams to cover the process design, the interface layout structures, databases architecture and its relationships using ERDs, etc.

3.5 Process Design

In software development projects process design describe the process of dividing the work to be done into distinct set of phases. Each phase may have one or more deliverables related to that specific phase/stage. In other words we can call it as the SDLC.

In this thesis the earlier chapters covered the initial phases of the SDLC including the problem definition, literature review and system analysis stages. Hereafter it describe the logical and technical architecture of the proposed system. More specifically all the work associated to the actual implementation of the project will be discussed in the below sections. First it has identified the existing Moodle design structure and then selected the needed modules and DB tables to be modified to match our primary requirement of making Moodle accessible for visually impaired students.

As the development is more towards into research and development all the work which is carried during system design and development will not be included in this documentation. Only the major work which is done and also required to understand the core structure of the work carried are only included for the readers of this thesis. Following sections will cover the logical breakdown/architecture of the system and the revised database structure of the system to cater both sighted and visually impaired students and teachers.

3.5.1 Refine Use case Diagrams and Use case Descriptions

Typical Use case diagrams use to define the events or actions take place related to a specific functionality and the involvement of user roles to those events. Below section is use to demonstrate the refined use case diagrams and the importance of those diagrams to get an idea about the implementation before the actual development of the proposed system begins. Note that the revised diagrams will only explain how to improve the accessibility of the Moodle LMS but not the content added to the platform.

There will be two separate set of use case diagrams listed in the below section. First set will be set of refined diagrams which are required to modify existing features of Moodle platform to cater for the accessibility requirements of the blind users and the second set of diagrams will be used to explain the new functionality which is going to develop to improve the accessibility of tool and contents.

Following Generalization relationship can be defined in Figure 3.1 to get idea on user roles of the proposed system. In this diagram we can note that the role of Student is further divided into two sub user roles Sighted Student and Blind Student. The aim of this process is to provide separate access and identification of exact Student type during various activities. It helps the tool and its content to be adjusted when a visually impaired student access the context. Same process will be used for visually impaired teachers as well. So ultimately the same Moodle instance will automatically restructure its platform and its content based on the user type/role.

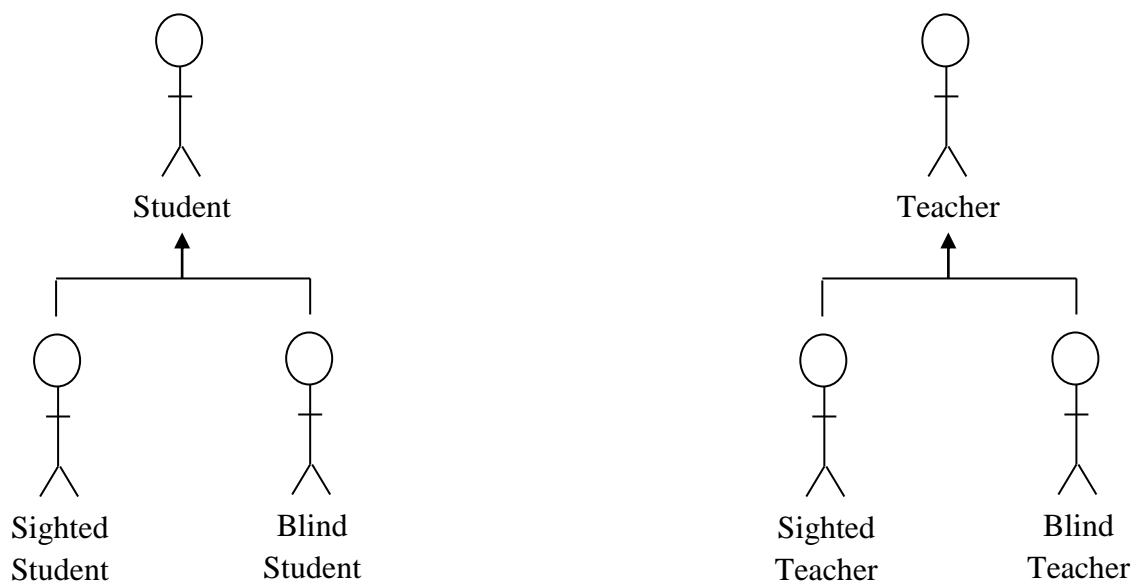


Figure 3.1 Generalization of Teacher and Student Roles

Following Figure 3.2 shows some functionalities which are available in the Moodle homepage. But for Guest users we are not able to recognize them as they are sighted or blind users because the guest user may belong to any of those user categories. So the target is to make the homepage content and navigation to accommodate any type of visitor to the site. To get some idea about the list of activities related to homepage functions are organized in the below use case diagram. The final system will be capable on giving full range of accessibility to the content provided under the homepage. The code changes which are going to introduce will be added to the Implementation chapter of this thesis.

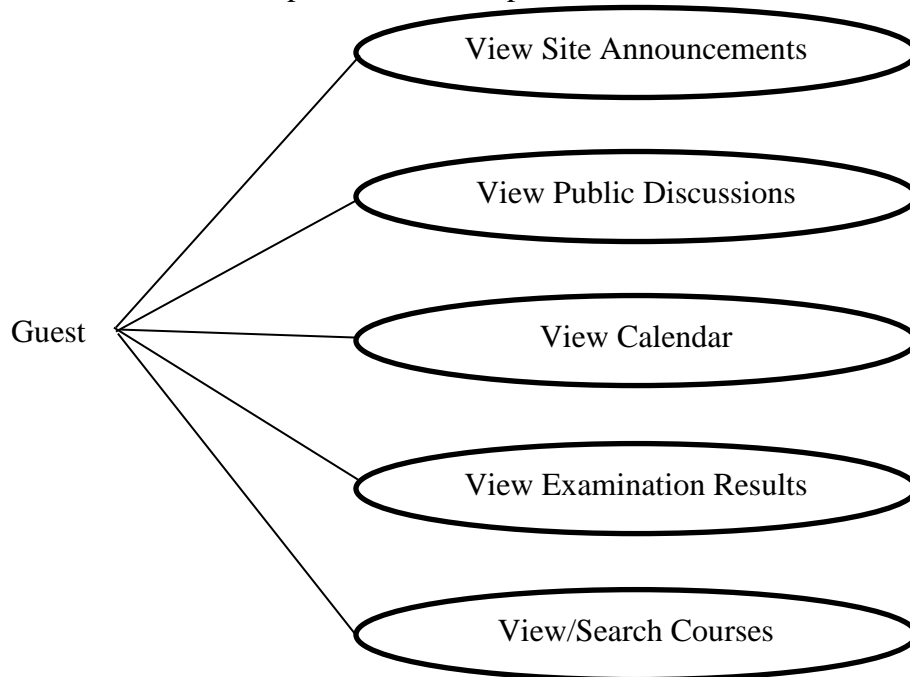


Figure 3.2 Use case for Guest User Role Functions in Homepage

Following use case diagram is used to define the functionalities related to Student user role. As we discussed earlier general Student role is inherited to the Sighted Student and Blind Student user roles. As all of the functions have to be performed after login into the portal. So the Login use case is start point where all functionality depends on that.

When considering the system login the “Login” will be the base use case and the “Get Specific User Type” will be the extended use case. It will be used to check the exact user type check whether the user belongs to sighted user category or blind user category. Then based on that content and platform will be automatically adjusted.

Similarly Teacher user role functions will also include the “Login” use case and it will be extended by the “Get Specific User Type” use case. Because in CSDB there are blind teachers as well. Our primary target is to enable O/L ICT subject course material on the developed platform and it is teach by a blind teacher in the school. So the solution which is going to be developed must cater for both Students as well as Teachers who are having visibility issues.

Following functions are main tasks which is covered under Moodle and are core functions related to online learning and shown in Figure 3.3. And the functions given in the diagram are grouped based on the relationship of functions with each other for easiness of handling related functionalities.

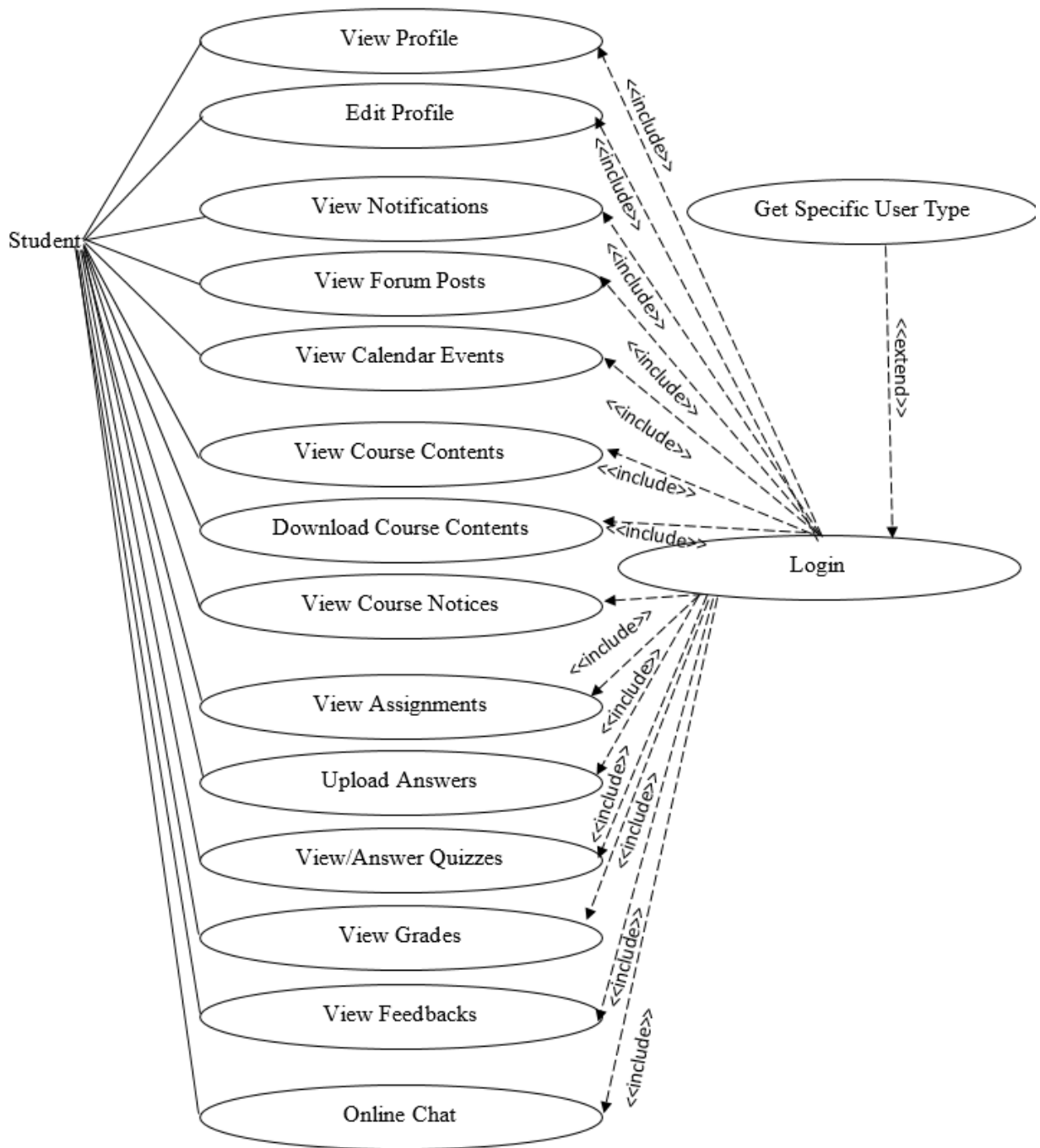


Figure 3.3 Use case for Student User Role Related Functions

Following the main functions that are related to Teacher user role. They are Add/Edit/Delete Notifications, Add/Edit/Delete Calendar Events, Add/Edit/Delete Course Materials, Add/Edit/Delete Course Notices, Add/Edit/Delete Assignments, Add/Edit/Delete Quizzes, Managing Links related to Upload Assignments, Submitting Grades and Feedbacks for Assignments and Quizzes, etc.

3.6 Class Diagrams

Related to basic course related operations following class diagram is drawn in Figure 3.4. With initial literature study we observed that there will be different time intervals we have to set separately for normal students and blind students when taking course related activities. Two main activities which are going to handle under this proposed solution are Assignments and Quizzes.

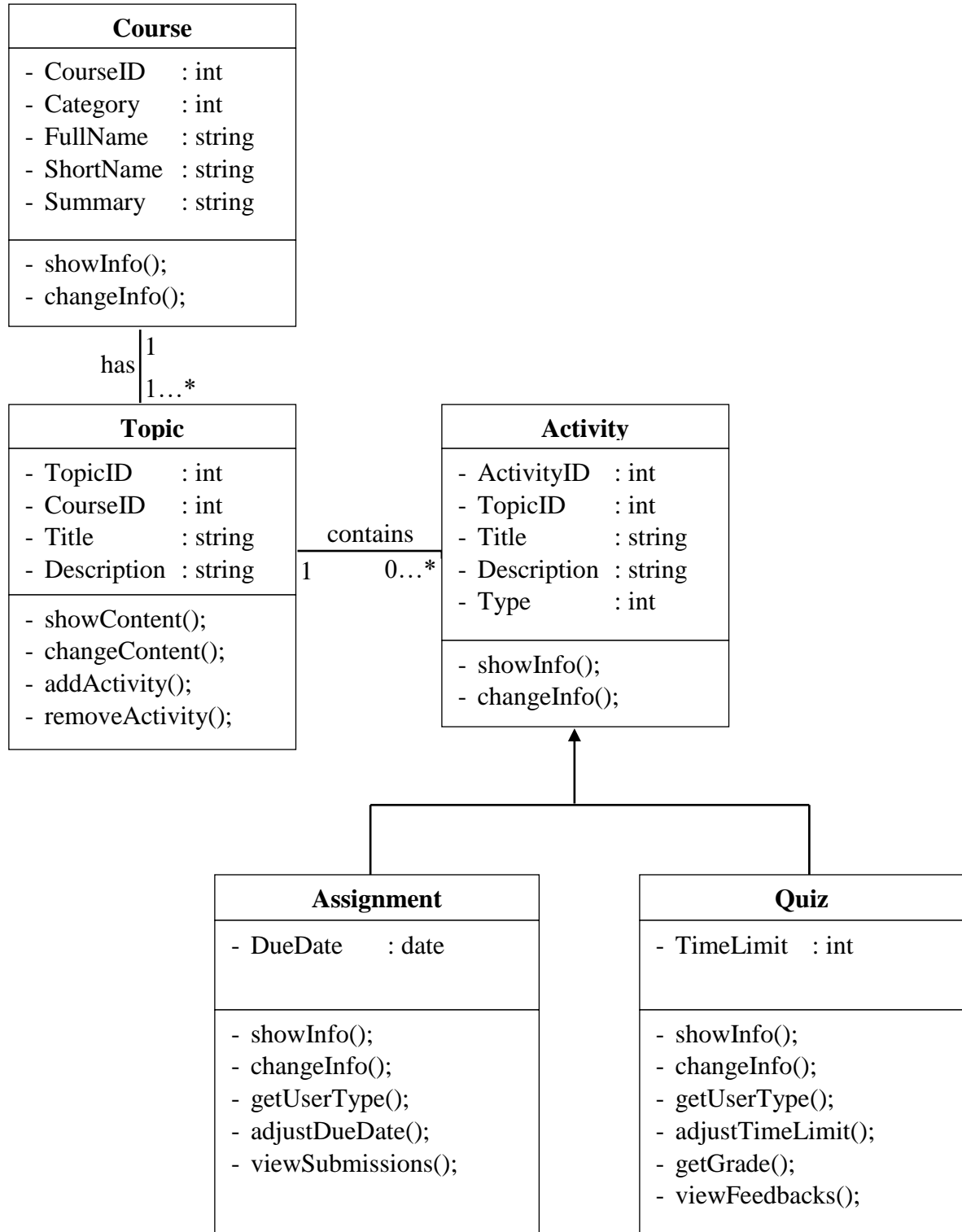


Figure 3.4 Class diagram for Student User Role Related Course Functions

Apart from the standard operations which are conducted related to courses, new attributes need to set when customizing the standard Moodle activities for blind students. Based on after identifying the user role after a successful login attempt thereafter timings will be adjusted based on the specific user role.

3.7 Database Design

There are no major modifications done on existing Moodle Database (DB) structure. While keeping the DB tables unchanged only few new fields were introduced to support the usage of existing Moodle environment by blind users. Once the following tables modified all the relevant places which access the data in those tables will be updated thereafter. The changes which are made will be briefly addressed in the following section and duly explained in the Implementation Chapter along with the reason behind to do such a modification.

The main reason not to do such big modification is because there are a lot of dependencies among those existing tables and are strongly recommended to keep them unchanged to allow unexpected error safe experience by the users. Existing Moodle database structure is separately attached in Appendix C: Moodle Database Structure section in this thesis.

There were 3 main modifications done to the following 3 tables.

- 1) mdl_assign - A new field added to keep due date for the blind students when they submit an assignment.

Field Name : duedate1
Data Type : bigint(10)

- 2) mdl_event - A new field added to keep maintain due date in calendar for the blind students.

Field Name : timestart1
Data Type : bigint(10)

- 3) mdl_quiz - A new field added to keep time limit for the blind students when they participate for quizzes.

Field Name : timelimit1
Data Type : bigint(10)

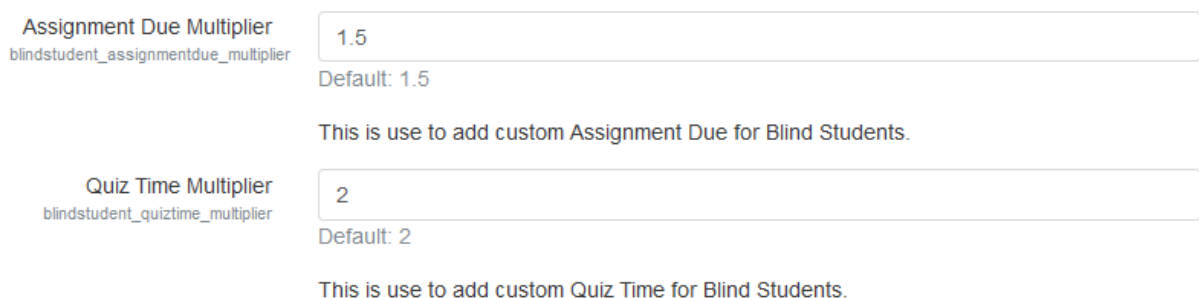
Chapter 4 : Implementation

This chapter covers the details of the implementation process of the proposed system. Modifying the core modules of existing system, developing the new features which are finalized during analysis stage, explanation of code modules, development platform & programming language used and the tools used for the development are explained as the content of this chapter. As the solution is web based the method of putting the system into practical use how the training is provided to the system users are also included and discussed in this chapter.

In e-Learning platform accessibility counts in both tool and its content available. So the implementation chapter content is also organized based on that. First part of the implementation chapter covers the new implementations and the changes that are made on the Moodle core modules and the second part of the chapter covers the necessary changes that are made when adding the course content to the Moodle environment.

4.1 Changes made on Existing Moodle Structure

Changes are made to “Course default settings” available under *Site administration* → *Courses* → *Course default settings* to add some custom settings related to course assessment when Blind Students take Assignments and Quizzes. Based on the identified factors during analysis, Blind Students will get 0.5 more times duration when considering Assignments and double the time duration when they provide answers for Quizzes. Following Figure 4.1 shows the interface changes made on “**Course default settings**” section.



The screenshot displays two custom settings in the Moodle interface. The first setting is "Assignment Due Multiplier" with a value of 1.5. Below it, the text reads "This is use to add custom Assignment Due for Blind Students." The second setting is "Quiz Time Multiplier" with a value of 2. Below it, the text reads "This is use to add custom Quiz Time for Blind Students." Both settings have their respective default values listed as 1.5 and 2.

Figure 4.1 Course default settings Custom Fields

In order to get the custom fields added into the above section following code and database changes are made. Code changes are made to the following existing files available in the “**admin**” and “**lang**” directories in the Moodle file repository.

admin/settings/courses.php

```
// Custom 1 (for blindstudent_assignmentdue_multiplier)

$temp->add(new admin_setting_configtext('blindstudent_assignmentdue_multiplier',
get_string('assignmentduemultiplier', 'admin'), get_string('assignmentduemultiplier_help',
'admin'), 1.5, PARAM_NUMBER));

// Custom 2 (for blindstudent_quiztime_multiplier)

$temp->add(new admin_setting_configtext('blindstudent_quiztime_multiplier',
get_string('quiztimemultiplier', 'admin'), get_string('quiztimemultiplier_help', 'admin'), 2,
PARAM_NUMBER));
```

Syntax of the **admin_setting_configtext()** function will be as follows;

```
admin_setting_configtext('tbl_config_field', get_string('lang_file_array_index_for_field_lbl',
'lang_file_name'), get_string('lang_file_array_index_for_field_help_txt', 'lang_file_name'),
default_value, validation_type)
```

Above code is used to add two new fields to the “**Course default settings**” page. First Custom field is used to specify the Assignment Due Multiplier of Blind Students and the Second Custom field is used to specify the Quiz Time Multiplier of Blind Students. **admin_setting_configtext()** function is used to add a new text field to the interface with the given name and the field label. **get_string()** method is used to grab the relevant label for the newly added form element. For that relevant language file is mapped as the second parameter of the **get_string()** function. First parameter value provided will be mapped with the linked string array in the language file. Apart from that the default value and the constraint to validate the value provided is also pass to the **admin_setting_configtext()** function. The term “**PARAM_NUMBER**” is used as the last parameter for the **admin_setting_configtext()** function and it will limit the system to only accept the numeric value for the specific field with or without decimals.

lang/en/admin.php

```
$string['assignmentduemultiplier'] = 'Assignment Due Multiplier';

$string['assignmentduemultiplier_help'] = 'This is use to add custom Assignment Due for
Blind Students.';
```

```
$string['quiztimemultiplier'] = 'Quiz Time Multiplier';

$string['quiztimemultiplier_help'] = 'This is use to add custom Quiz Time for Blind Students.';
```

Following two records under the “id” 457 and 458 have been added to the “mdl_config” table to accommodate the required changes made to the above section are shown in Figure 4.2.

			id	name	value	
<input type="checkbox"/>				455	registerauth	
<input type="checkbox"/>				456	themelegacy	boost
<input type="checkbox"/>				457	blindstudent_assignmentdue_multiplier	1.5
<input type="checkbox"/>				458	blindstudent_quiztime_multiplier	2

Figure 4.2 mdl_config Table New Entries for Course default settings Customization

Next modification is made to the database table structure of “mdl_assign” table to store and maintain then assignment due dates of Blind Students. You can note in Figure 4.3 a new field named “duedate1” is added. To maintain the quiz time limits of Blind Students a new file named “timelimit1” is added to the “mdl_quiz” table, see Figure 4.4. Each time new Assignment or Quiz is added then due dates and time limits will be automatically set for Blind Students based on the multiplier value that we set based on the above section. As an example if we set the time limit as 10 minutes for a specific Quiz then it will store the “timelimit” as “600” (in milliseconds) for the Sighted Students and the “timelimit1” as “1200” for the Blind Students.

Apart from that each time when a new Assignment is added/modified there will be reference made in the “mdl_event” table. It is usually used to handle Calendar Events and Upcoming Events in the Moodle homepage. As shown in Figure 4.5 a new field named “timestart1” is added to “mdl_event” table to accommodate that change to support Blind Students event display on the homepage. This change is only related to Assignments not for Quizzes.

<input type="checkbox"/>	11	duedate	bigint(10)	No	0
<input type="checkbox"/>	12	duedate1	bigint(10)	No	0

Figure 4.3 mdl_assign Table New Field for Assignment duedate1 Customization

<input type="checkbox"/>	8	timelimit	bigint(10)	No	0
<input type="checkbox"/>	9	timelimit1	bigint(10)	No	0

Figure 4.4 mdl_quiz Table New Field for Quiz timelimit1 Customization

<input type="checkbox"/>	12	timestart	bigint(10)	No	0
<input type="checkbox"/>	13	timestart1	bigint(10)	No	0

Figure 4.5 mdl_event Table New Field for Assignment timestart1 Customization

In order to implement the custom functionality of Quiz “**timelimit1**” for Blind Students following code and database changes are made. Code changes are made to the following existing files available in the “**course**” and “**mod/quiz**” directories in the Moodle file repository.

mod/quiz/lang/en/quiz.php

```
$string['timelimit'] = 'Time limit';
$string['timelimit1'] = 'Time limit for Blind Students';
```

mod/quiz/mod_form.php

```
// Time limit1. (Custom Time limit for Blind Students).
$mform->addElement('hidden', 'timelimit1', get_string('timelimit1', 'quiz'), array('optional' => true));
```

Above code is used to a new custom field for the “**Quiz**” form. First parameter indicate the type of the field and the field will act as a hidden field. Second parameter is the field name as it must be same as the database table field to map with. Third parameter is the field label. But in this case it is not relevant as our field is a hidden field. And the last parameter indicate that the field is an optional field. Which means value for this field must pass to the database table if and only if “**Time Limit**” is “*Enable*”.

In order to implement the custom functionality of Assignment “**duedate1**” for Blind Students following code and database changes are made. Code changes are made to the following existing files available in the “**course**” and “**mod/assign**” directories in the Moodle file repository.

mod/assign/lang/en/assign.php

```
$string['duedate'] = 'Due date';
$string['duedate1'] = 'Due date for Blind Students';
```


mod/assign/mod_form.php

```
// Due date1. (Custom Due date for Blind Students).  
  
$name = get_string('duedate1', 'assign');  
  
$mform->addElement('hidden', 'duedate1', $name, array('optional'=>true));
```

Above code is used to a new custom field for the “**Assignment**” form. First parameter indicate the type of the field and the field will act as a hidden field. Second parameter is the field name as it must be same as the database table field to map with. Third parameter is the field label. But in this case it is not relevant as our field is a hidden field. And the last parameter indicate that the field is an optional field. Which means value for this field must pass to the database table if and only if “**Due Date**” is “*Enable*”.

course/modedit.php

```
// <-- Begin of New Block Added to Customize Blind Student duedate & timelimit -->  
  
//print_r($fromform);  
  
//echo $fromform->duedate;  
  
//echo date("Y-m-d H:i", $fromform->duedate);  
  
//echo $fromform->timelimit;  
  
// mdl_assign table relate Insert / Update  
  
if(isset($fromform->duedate) && !empty($fromform->duedate))  
{  
    if($fromform->duedate > 0)  
    {  
        $start_datetime =  
            new DateTime(date("Y-m-d H:i", $fromform->allowsubmissionsfromdate));  
        $end_datetime = new DateTime(date("Y-m-d H:i", $fromform->duedate));  
  
        // Calculate the days diff between allowsubmissionsfromdate and duedate
```

```

    $days = $start_datetime->diff($end_datetime)->format('%a');

    // Getting the no of due days for Blind Students

    $blind_students_days =

        $days * $CFG->blindstudent_assignmentdue_multiplier;

    // Calculate new timestamp of due date 1 for Blind Students

    $fromform->duedate1 = intval($fromform->allowsubmissionsfromdate +
(60*60*24*$blind_students_days));

    }

    elseif($fromform->duedate == 0)

    {

        $fromform->duedate1 = 0;

    }

}

// mdl_quiz table relate Insert / Update

if(isset($fromform->timelimit) && !empty($fromform->timelimit))

{

    if($fromform->timelimit > 0)

    {

        $fromform->timelimit1 =

            $fromform->timelimit * $CFG->blindstudent_quiztime_multiplier;

    }

    elseif($fromform->timelimit == 0)

    {

        $fromform->timelimit1 = 0;

```

```

    }

}

//print_r($fromform);

//echo $fromform->duedate1;

//echo date("Y-m-d H:i", $fromform->duedate1);

//echo $fromform->timelimit1;

//exit;

// <-- End of New Block Added to Customize Blind Student duedate & timelimit -->

// Custom Update for Assignments / Events

if($fromform->modulename == 'assign')
{
    $customSQL = "UPDATE mdl_assign SET duedate1='".$fromform->duedate1.'"
WHERE id='".$fromform->instance.'";

    $DB->execute($customSQL);

    $customSQL1 = "UPDATE mdl_event SET timestart1='".$fromform->duedate1.'"
WHERE instance='".$fromform->instance.'";

    $DB->execute($customSQL1);
}

```

Above code is used to inject the value for the “**timelimit1**” field in the “**mdl_quiz**” table when adding a new quiz and updating an existing quiz and “**duedate1**” field in the “**mdl_assign**” table when adding a new assignment and updating an existing assignment. It is related with the new custom fields added to the “**Quiz**” form and “**Assignment**” form. Both functions ensure that a value is set to the “**timelimit**” field with the **if(\$fromform->timelimit > 0)** condition. If a value is set and it is greater than “**0**” then it will calculate and set a value

for the “**timelimit1**” index in the “**\$fromform**” data array. Otherwise if no value is set to the “**timelimit**” then “**timelimit1**” value is also set to “**0**”. When considered the “**duedate**” field with the **if(\$fromform->duedate > 0)** condition works in a similar fashion same as the above mentioned functionality in “**Quiz**” section. If a value is set and it is greater than “**0**” then it will calculate and set a value for the “**duedate1**” index in the “**\$fromform**” data array. Otherwise if no value is set to the “**duedate**” then “**duedate1**” value is also set to “**0**”.

Because of both “**Quiz**” and “**Assignment**” work on the same “**modedit.php**” file additional condition is written to capture the exact data submission from elements. And a custom Structured Query Language (SQL) statement is used when setting the value for the “**duedate1**” field in the “**mdl_assign**” table because both “**add_moduleinfo()**” and “**update_moduleinfo()**” functions skip the value add/modify during Assignment create and update. It is triggered with the “**if(\$fromform->modulename == 'assign')**” condition. In addition to that to set the value for the “**timestart1**” field in “**mdl_event**” table same condition is used.

```
if(isset($fromform->duedate) && !empty($fromform->duedate))
{
    // Logic of formulating duedate1
}
if(isset($fromform->timelimit) && !empty($fromform->timelimit))
{
    // Logic of formulating timelimit1
}
```

Commented source is used for testing purpose and to trace the values before and after setting, when sending data to the database table. Resulting database entry will look like shown in the below Figure 4.6, Figure 4.7 and Figure 4.8.

	id	course	name	intro	introformat	timeopen	timeclose	timelimit	timelimit1
<input type="checkbox"/> Edit Copy Delete	1	2	Quiz on Data and Information		1	0	0	600	1200

Figure 4.6 mdl_quiz Table Data with timelimit1

id	course	name	intro	introformat	alwaysshowdescription	nosubmissions	submissiondrafts	sendnotifications	sendlatenotifications	duedate	duedate1
1	2	Write another example each for the characteristics...	<p>Write another example each for the characterist...	1	1	0	0	0	0	1525195800	1530297000
2	2	Find information on computer history and make a re...	<p>Find information on computer history and make a...	1	1	0	0	0	0	1522434600	1526279400
3	2	Assignment on Applications of Information and Comm...	<p>Observe other instances where ICT is used in bu...	1	1	0	0	0	0	1522434600	1526279400
4	2	Submit a Short Note on this Topic	<p>Prepare and submit a short note on this topic. ...	1	1	0	0	0	0	1527874200	1531377000

Figure 4.7 mdl_assign Table Data with duedate1

id	name	description	format	courseid	groupid	userid	repeatid	modulename	instance	eventtype	timestart	timestart1
2	Find information on computer history and make a re...	<p>Find information on computer history and make a...	1	2	0	2	0	assign	2	due	1522434600	1526279400
3	Assignment on Applications of Information and Comm...	<p>Observe other instances where ICT is used in bu...	1	2	0	2	0	assign	3	due	1522434600	1526279400
4	Write another example each for the characteristics...	<p>Write another example each for the characterist...	1	2	0	2	0	assign	1	due	1525195800	1530297000
5	Submit a Short Note on this Topic	<p>Prepare and submit a short note on this topic. ...	1	2	0	2	0	assign	4	due	1527874200	1531377000

Figure 4.8 mdl_event Table Data with timestart1

Next set of modification is made on “**view.php**” file available on “**mod/quiz**” directory to inject the newly set “**timelimit1**” on top of “**timelimit**” once students access the quizzes available under courses. Based on the user role it will automatically adjust the time limit given to complete the specific quiz. When a Blind Student access their enrolled courses and take a quiz, their time limit will be set from the value taken from “**timelimit1**” field in the “**mdl_quiz**” table. Consider the following changes made on the quiz view page.

mod/quiz/view.php

```
// Changing Quiz timelimit based on user role

//print_r($USER);

$context = get_context_instance(CONTEXT_COURSE, $course->id);

$roles = get_user_roles($context, $USER->id, true);

//print_r($roles);
```

```

$role = key($roles);

//print_r($role);

if(!empty($roles[$role]->name) && $roles[$role]->name == "Blind Student")

{

    //print_r($quiz);

    $quiz->timelimit = $quiz->timelimit1;

    //print_r($quiz);

    //exit;

}

```

“**get_context_instance()**” function is used to get the information related to a specific course and that course information is passed as a parameter for the “**get_user_roles()**” function along with the currently logged in users user id to get that users user role in that context. Then the user role is checked using the “**if(!empty(\$roles[\$role]->name) && \$roles[\$role]->name == "Blind Student")**” condition to ensure that the users role is “**Blind Student**”. If so “**timelimit**” is replaced with “**timelimit1**”. With reference to the Figure 4.5 the “**timelimit1**” value set as “**1200**” is then converted and display in the quiz view page as shown in Figure 4.9.

Quiz on Data and Information

Time limit: 20 mins

Grading method: Highest grade

Attempt quiz now

Figure 4.9 View Quiz with timelimit1

Following modification is made on “**lib.php**” file available on “**mod/assign**” directory to inject the newly set “**duedate1**” on top of “**duedate**” once students access the assignments available on courses in the dashboard under the toggle section “**You have assignments that need attention**”. Based on the user role it will automatically adjust the due date given to submit the answers for the specific assignment. When a Blind Student access their enrolled courses and open the assignment answer submit page, their due date will be set from the value

taken from “**duedate1**” field in the “**mdl_assign**” table. Consider the following changes made on the dashboard page and all the other relevant pages where due date is visible and effective.

mod/assign/lib.php

```
$roles = get_user_roles($context, $USER->id, true);

$role = key($roles);

if(!empty($roles[$role]->name) && $roles[$role]->name == "Blind Student")
{
    //echo $assignment->duedate1;exit;

    $assignment->duedate = $assignment->duedate1;
}
```

Above code block is mostly similar to the changes made on quiz related pages. And based on the user role value of “**duedate1**” will be assigned to “**duedate**” field.

Apart from the above section there are two more sections in the Moodle which has reflection to the modification which is made on Assignments for Blind Students. Those are Calendar module and Upcoming Events module. Because in those sections also it display the data based on the “**duedate**” field in the “**mdl_assign**” table. Following section describe the modification did on “**lib.php**” file on “**calendar**” directory.

calendar/lib.php

```
// Modification for Blind Students in calendar_get_events() function

if($withduration) {

    $timeclause = '((e.timestart >= '.$tstart.' OR e.timestart + e.timeduration > '.$tstart.')
AND e.timestart <= '.$tend.') OR ((e.timestart1 >= '.$tstart.' OR e.timestart1 + e.timeduration
> '.$tstart.') AND e.timestart1 <= '.$tend.>');

}

else {
```

```
$timeclause = '(e.timestart >= '.$tstart.' AND e.timestart <= '.$tend.') OR (e.timestart1  
>= '.$tstart.' AND e.timestart1 <= '.$tend.);  
  
}
```

Above code block is written to select the Calendar Events for Blind Students to display them in the Calendar block in Moodle homepage.

```
// Modification in calendar_get_mini() function  
  
// Changing the Assignment Due Date for Blind Students on Calendar  
  
$context = get_context_instance(CONTEXT_COURSE, $event->courseid);  
  
$roles = get_user_roles($context, $USER->id, true);  
  
$role = key($roles);  
  
if(!empty($roles[$role]->name) && $roles[$role]->name == "Blind Student")  
  
{  
  
    $event->timestart = $event->timestart1;  
  
    //echo $event->timestart;  
  
    //exit;  
  
}
```

Above code block is written to customize the list of the Calendar Events for Blind Students to display them in the Calendar block in Moodle homepage.

```
// Modification in calendar_get_upcoming() function  
  
// Changing the Assignment Due Date for Blind Students on Upcoming Events  
  
$context = get_context_instance(CONTEXT_COURSE, $event->courseid);  
  
$roles = get_user_roles($context, $USER->id, true);  
  
$role = key($roles);  
  
if(!empty($roles[$role]->name) && $roles[$role]->name == "Blind Student")
```



```

{

    $event->timestart = $event->timestart1;

    //echo $event->timestart;

    //exit;

}

```

Above code block is written to customize the list of the Upcoming Events for Blind Students to display them in the Upcoming Events block in Moodle homepage. Similar modification is made on the “**show_day()**”, “**show_month_detailed()**” and “**show_upcoming_events()**” methods in “**renderer.php**” file available on “**calendar**” directory to show list of Events in the “**Month**” view on “**Calendar**” page. It also check the user role and display the event due by replacing the value “**timestart**” by the “**timestart1**” in “**mdl_event**” table.

Final modification is made on the “**renderer.php**” in “**mod/assign**” directory when Blind Student view the exact Assignment page, to replace the “**duedate**” field value with the “**duedate1**” field value.

mod/assign/renderer.php

```

// Get duedate1 for Blind Students

//echo $submission->assignment;

$assign = $DB->get_record('assign', array('id' => $submission->assignment), 'duedate1');

//print_r($assign);

//exit;

// Changing Assignment duedate based on user role

//print_r($USER);

$context = get_context_instance(CONTEXT_COURSE, $status->courseid);

$roles = get_user_roles($context, $USER->id, true);

//print_r($roles);

```

```

$role = key($roles);

//print_r($role);

if(!empty($roles[$role]->name) && $roles[$role]->name == "Blind Student")

{

    $duedate = $assign->duedate1;

    //echo $duedate;

    //exit;

}

```

First part of the code is written to get the “**duedate1**” value loaded. Then as usual second part of the code check whether the user role is Blind Student and based on that it will replace the “**duedate**” value with the “**duedate1**” value. So the list of Assignments for Sighted Students and Blind Students will be as in Figure 4.10 and Figure 4.11.

Information and Communication Technology

 You have assignments that need attention

Assignment: [Write another example each for the characteristics of information](#)

Due date: Tuesday, 1 May 2018, 11:00 PM

My submission: Not submitted yet, Not graded

Assignment: [Submit a Short Note on this Topic](#)

Due date: Friday, 1 June 2018, 11:00 PM

My submission: Not submitted yet, Not graded


Assignment: [Assignment on Applications of Information and Communication Technology](#)

Due date: Saturday, 31 March 2018, 12:00 AM

My submission: Not submitted yet, Not graded

Figure 4.10 View Assignment List for Sighted Students with duedate

Information and Communication Technology

 You have assignments that need attention

Assignment: [Write another example each for the characteristics of information](#)

Due date: Saturday, 30 June 2018, 12:00 AM

My submission: Not submitted yet, Not graded

Assignment: [Submit a Short Note on this Topic](#)

Due date: Thursday, 12 July 2018, 12:00 PM

My submission: Not submitted yet, Not graded

Assignment: [Assignment on Applications of Information and Communication Technology](#)

Due date: Monday, 14 May 2018, 12:00 PM

My submission: Not submitted yet, Not graded

Figure 4.11 View Assignment List for Blind Students with duedate1

Following set of changes are made on the “**login.mustache**” file available on “**lib/templates**” directory and “**login.mustache**” file available on “**theme/boost/templates/core**” directory. As the login interface is already created using those two files, only “**accesskey**” attribute is added in all relevant places on those two files. The following Table 6 gives the details of access keys which are added to the elements of the interface elements.

Table 6: Login Form Elements & Access Keys

Element	Type of Element	Access Key
Username	input: text	u
Password	input: password	p
Remember username	input: checkbox	r
Forgotten your username or password?	anchor	f
Login	input: button	l

Some of the coding changes did on the above mentioned file will be as follows.

```
<input type="text" name="username" id="username"
    class="form-control"
    accesskey="u"
    value="{{ username }}"
    placeholder="{{ #quote }}{{ ^canloginbyemail }}{{ #str }}username{{ /str }}{{ /canloginbyemail }}{{ #canloginbyemail }}{{ #str }}usernameemail{{ /str }}{{ /canloginbyemail }}{{ /quote
}}>
<input type="password" name="password" id="password" accesskey="p" value=""
    class="form-control"
    placeholder="{{ #quote }}{{ #str }}password{{ /str }}{{ /quote }}
    {{ ^passwordautocomplete }}autocomplete="off"{{ /passwordautocomplete }}>
<input type="checkbox" name="rememberusername" id="rememberusername" accesskey="r"
value="1" {{ #username }}checked="checked"{{ /username }} />
```

Before moving into the New Implementations made on Moodle following changes are made on “**outputrenderers.php**” in “**lib**” directory and “**config.php**” file in the “**root**” directory to inject a custom JS and a label for copyright information in the footer section in all pages.

config.php

```
$CFG->devby = 'Namal Darshana Balasuriya';
```

lib/outputrenderers.php

```
// function standard_end_of_body_html()

// To display custom developer info & navigation options for Blind Students

$output .= "<br />&copy; Copyright " . date('Y') . ". Developed By " . $CFG->devby;

$output .= file_get_contents($CFG->wwwroot . '/lib/anchor.php');

$output .= file_get_contents($CFG->wwwroot . '/lib/button.php');return $output;

// function footer()

// Standard footer modification to inject custom javascript file to all pages

//return $output . $footer;

return $output . "<script type='text/javascript' src='" . $CFG->wwwroot .
                "/lib/javascript/script.js"></script>" . $footer;
```

One primary concern on accessibility matters of Moodle infrastructure is navigation limitation for Blind users. The following section describe the changes made on Moodle structure to facilitate accessibility on platform and its content.

4.2 New Implementations made on Moodle

4.2.1 New Navigation Functionality

Following implementation is made to overcome the site navigation problem faced by the blind users. For that a custom JS file and a Bootstrap Modal component is used. Aim of this functionality is to read all navigation links available in each page and to provide them as a list where blind users can pick a specific option that they want to visit into. JS file named “**script.js**” is placed under a newly created directory under “**lib**” directory named

“**javascript**” and the Bootstrap Modal is located in a newly created PHP script file called “**anchor.php**” in “**lib**” directory. And a reference to load those files in each page that the user access is made on “**outputrenderers.php**” in “**lib**” as discussed in the previous section.

lib/anchor.php

```
<?php
/**
    Author      :      Namal Darshana Balasuriya
    Email       :      namal_nais@yahoo.com
    Date        :      19/12/2017
    Version     :      v1.0
*/
require_once('./config.php');
global $CFG;
//print_r($CFG);exit;
?>
<button type="button" accesskey="n" id="btnNav" class="btn btn-info btn-lg" data-
toggle="modal" data-target="#myModal">Navigation Options</button>
<!-- Block of Navigation Options for Blind Students -->
<div class="modal fade" id="myModal" tabindex="-1" role="dialog" aria-
labelledby="myModalLabel" aria-hidden="true" style="width: auto">
    <div class="modal-dialog">
        <div class="modal-content">
            <div class="modal-header" style="color: #3a3a3a !important;">
                <h4 class="modal-title" id="myModalLabel">Pick you Option Jump to...</h4>
            </div>
```

```

    <div id="modal-body" class="modal-body" style="color: #3a3a3a !important;">No
Options!</div>

    <div class="modal-footer"><button type="button" accesskey="c" class="btn btn-
primary" data-dismiss="modal">Close</button>

    </div>

</div>

</div>

</div>
</div>

```

Above code is written based on the Bootstrap Modal concept and some of the coding is modified based on the need for blind users. As an example two “**accesskey**” values were defined to load and close those Navigation Options block (“**n**” top popup the modal and “**c**” to close the modal window).

lib/javascript/script.js

```

// To create accessibility options for the Blind Students

document.addEventListener("DOMContentLoaded", function(){

    // list all anchor tags

    var list = document.getElementsByTagName("a");

    // removing duplicates, skip options and link to moodle site

    let hrefArr = [];

    let textArr = [];

    for (var i = 0; i < list.length; i++)

    {

        if(list[i].href.trim() != " && list[i].text.trim() != " && !list[i].href.includes("#")
&& !list[i].href.includes("moodle.org") && !list[i].href.includes("redirect=0"))

        {

```

```

        if(hrefArr.indexOf(list[i].href) == -1)
        {
            // setting the access key for Log in as 'l'
            if(list[i].text == 'Log in')
            {
                list[i].setAttribute('accesskey', 'l');
            }
            hrefArr.push(list[i].href);
            textArr.push(list[i].text);
        }
    }

    // setting home page link to the first place and remove it from the end
    hrefArr[0] = hrefArr[hrefArr.length-1];
    textArr[0] = textArr[textArr.length-1];

    hrefArr.pop();
    textArr.pop();

    // display list of options
    var optModal = document.getElementById("modal-body");
    var strCustom = "";
    for (var i = 0; i < hrefArr.length; i++)
    {
        // setting a custom label for each
        var frontLbl = "";

```

```
var strURL = hrefArr[i];

switch(true)
{
    case strURL.includes("/user/"):
        frontLbl = 'User Block';
        break;

    case strURL.includes("/grade/"):
        frontLbl = 'Report Block';
        break;

    case strURL.includes("/message/"):
        frontLbl = 'Message Block';
        break;

    case strURL.includes("/course/"):
        frontLbl = 'Course Block';
        break;

    case strURL.includes("/assign/"):
        frontLbl = 'Assignment';
        break;

    case strURL.includes("/calendar/"):
        frontLbl = 'Calendar Block';
        break;

    case strURL.includes("/time="):
        frontLbl = 'Calendar Block';
        break;
}
```



```

        default:

            frontLbl = 'Site';

        }

        //strCustom += strURL + " : " + textArr[i] + "<br />";

        strCustom += (i+1) + ") <a href=\"" + strURL + "\">" + frontLbl + ": " +
textArr[i] + "</a><br />";

    }

    optModal.innerHTML = strCustom;

});

```

Above code is written collect all the anchor tags to a list in a specific page after the page has been loaded fully. For that “**document.addEventListener("DOMContentLoaded", function(){**” event listener method is used. After that next code block is written to remove duplicates, remove skip options and links to Moodle site. And two new JS arrays created to hold the entries links and text separately. “**hrefArr**” array is used to maintain list of link URLs and “**textArr**” is used to maintain list of link text of those URLs. The “**if(list[i].href.trim() != " && list[i].text.trim() != " && !list[i].href.includes("#") && !list[i].href.includes("moodle.org") && !list[i].href.includes("redirect=0"))**” condition is used to handle that work. Before generating the list of navigation options, link to the home page is added to the first entry and removed from the last entry from the two arrays. To map and get a meaningful label to the front of the link text JS switch block is used. Finally prepared list of links are then embedded into the text block of the modal using “**innerHTML**” property. Then the resulting block will be shown as the following Figure 4.12. User will get a “**Navigation Options**” button with the access key “**n**” to trigger the click event of the button.

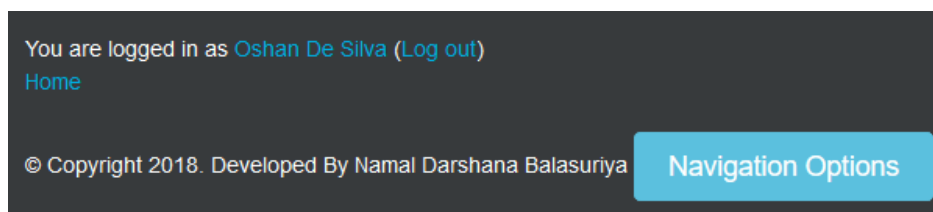


Figure 4.12 Navigation Options Button for Blind Students in Moodle Footer

It will also set the access key for “**Log in**” as “**I**” using the above script. Once they trigger the button click using the given access key, then they will get the list of all navigation options like

in Figure 4.13 based on the page that they are currently working on. When a user press the “TAB” key from the keyboard they can choose the section that they want to visit into after they hear the link text with support of NVDA screen reader using their headphones or speaker set.

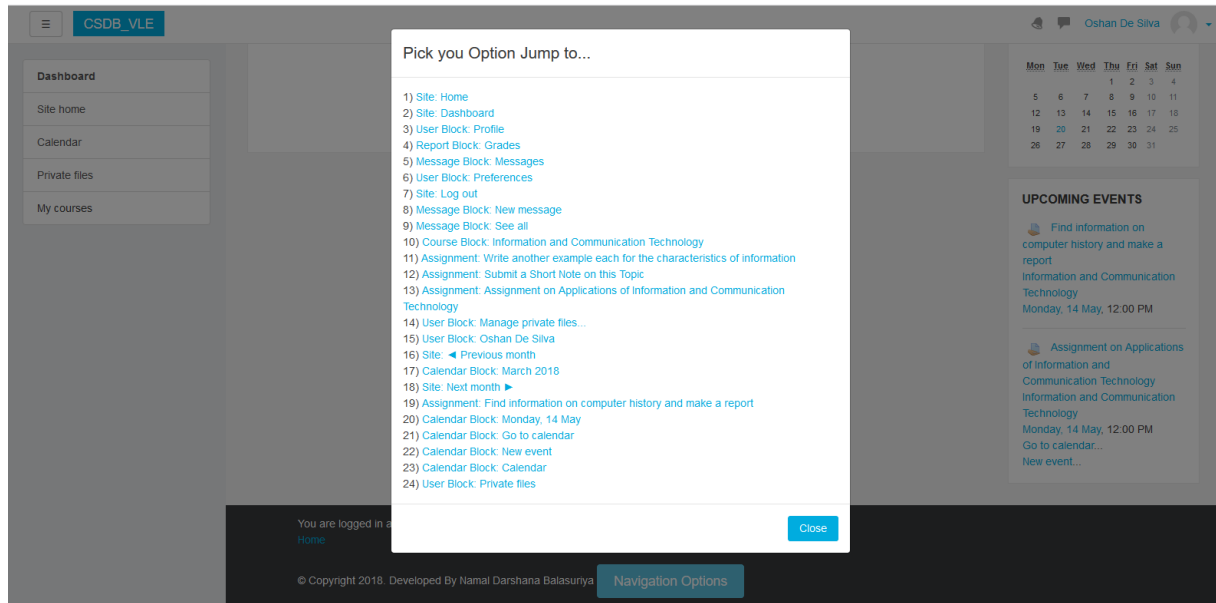


Figure 4.13 Navigation Options Modal for Blind Students

Similar approach is used to provide a list of buttons and associated access keys for them to be notified to the blind users. Same as the Bootstrap Modal used for Navigation Options list another Bootstrap Modal component is used to show list of buttons on each interface and their access keys. Another file called “**button.php**” is loaded using “**outputrenderers.php**” file to the footer section of each page. And then new code block is inserted to the same “**script.js**” file to handle list of buttons and their access key displaying logic. Following piece of code is added to the “**script.js**” file.

```
// list all buttons

var blist = document.getElementsByTagName("button");

//alert(blist.length);

// removing unwanted buttons

let btnArr = [];

for (var i = 1; i < blist.length; i++)

{
```

```

        if(!blist[i].textContent.includes("Close") && !blist[i].textContent.includes("Exit") &&
!blist[i].textContent.includes("Navigation Options") && !blist[i].textContent.includes("Get
Buttons"))

        {

            btnArr.push(blist[i]);

        }

    }

//alert(btnArr.length);

if(btnArr.length > 0)

{

    var optModal1 = document.getElementById("modal1-body");

    var strCustom1 = "";

    for (var i = 0; i < btnArr.length; i++)

    {

        // setting a custom accesskey for each

        var strCaption = btnArr[i].textContent;

        var strAccessKey = btnArr[i].textContent.charAt(0).toLowerCase();

        var btn = document.getElementById(btnArr[i].id);

        if(btn.getAttribute('accesskey') == " || btn.getAttribute('accesskey') == null)

        {

            btn.setAttribute('accesskey', strAccessKey);

        }

    }

    // generating a list of buttons with accesskeys

```

```

        //strCustom1 += strCaption + " : " + strAccessKey + "<br />";

        strCustom1 += (i+1) + ") <a href='void(0);'>Button: " + strCaption + ",
Access Key: " + strAccessKey + "'</a> <br />";

    }

    optModal1.innerHTML = strCustom1;

}

```

Apart from generating the list it will carefully analyze the buttons which is used for Modals and will remove them initially before generating the list. Because those buttons are not related to basic usage of Moodle environment but specially customized for blind users to improve accessibility for them. Before setting the “**accesskey**” property for each button, first it will get the button caption loaded to a variable and then the first character of that button caption is converted to lower case and then assign to the button using “**setAttribute()**” method. It will ensure that whether an access key is already available for the button, if not newly created access key is set to the relevant button.

Finally a list of buttons and their access keys will be listed in the Modal so user would be notified with the Button caption and the access key. So when user want to perform a button click they can use the access key available with that button. It is highly important for the blind users so they can easily do what they want liked with the functionality of that button. To get the list of available buttons in each page access key “**b**” is used. Following Figure 4.14 shows how those list of buttons appear in the Modal window. When a user press “**TAB**” key it will pronounce the button captions and access keys by using the NVDA tool.

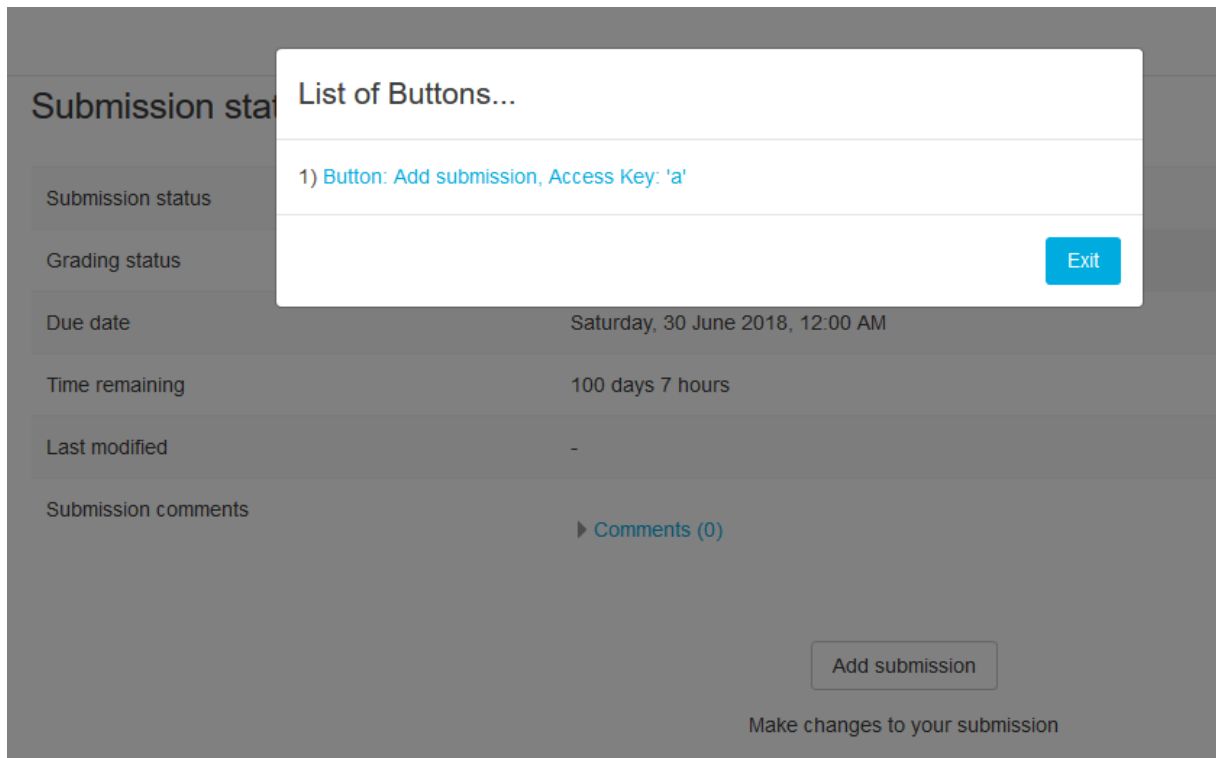


Figure 4.14 List of Buttons Modal for Blind Students

4.2.2 New Content Rendering Functionality

Above sections mainly concern about how to make the Moodle tool accessible to visually impaired users. Now it is time to consider about how the content related changes are going to make because accessibility issues are still need to be addressed as far as considering the content accessibility.

Generally screen readers are capable of handling basic text paragraphs, headings and lists items by default. There are various keyboard shortcuts exists and documented in Using NVDA to Evaluate Web Accessibility [48] and are going to include as a reference in User Manual section.

But yet there are some attention require in areas such as image handling and table data handling. They are usually considered as 2D structures where screen readers face some problems when interpreting those kind of context.

There are no ways that visually impaired users can read and understand images and what is meant by those images. As in such situations we have to deal with “**alt**” (alternate text) attribute available with “****” tag. Moodle platform supports defining a description text during the time of adding images to the course content but during inspecting the coding,

noticed that it only consist of “**alt**” attribute but not “**title**” attribute alone with the “****” tag. Based on the initial study we got to know that there are some browsers which are not capable on rendering “**alt**” attribute alone. So first there are some code changes which are done to modify to embed “**title**” attribute and a value for that based on what we have provided to the “**alt**” attribute. Course content creators must be wise enough to add alternate text when they add new image to the content always. It will not be effective if there are images with no alternate text provided. Included some extra scripts to the “**script.js**” file to handle the desired functionality. Consider the following code block.

```
// list all images

var ilet = document.getElementsByTagName("img");

//alert(ilet.length);

// removing images which doesn't contain "alt" attribute and setting "title" attribute

for (var i = 0; i < ilet.length; i++)

{

    if(ilet[i].getAttribute('alt').trim() != "" && ilet[i].getAttribute('alt').trim() != null)

    {

        //alert(ilet[i].getAttribute('alt'));

        ilet[i].setAttribute('title', ilet[i].getAttribute('alt'));

    }

}

}
```

Like we did earlier it will load all the images in the currently accessing page and then check whether alternate text is provided, if so then it will set the value for the “**title**” attribute using “**setAttribute()**” method. You can note from the following Figure 4.15 how the code change will react on the coding before and after adding the new content adjustment coding while rendering the page.

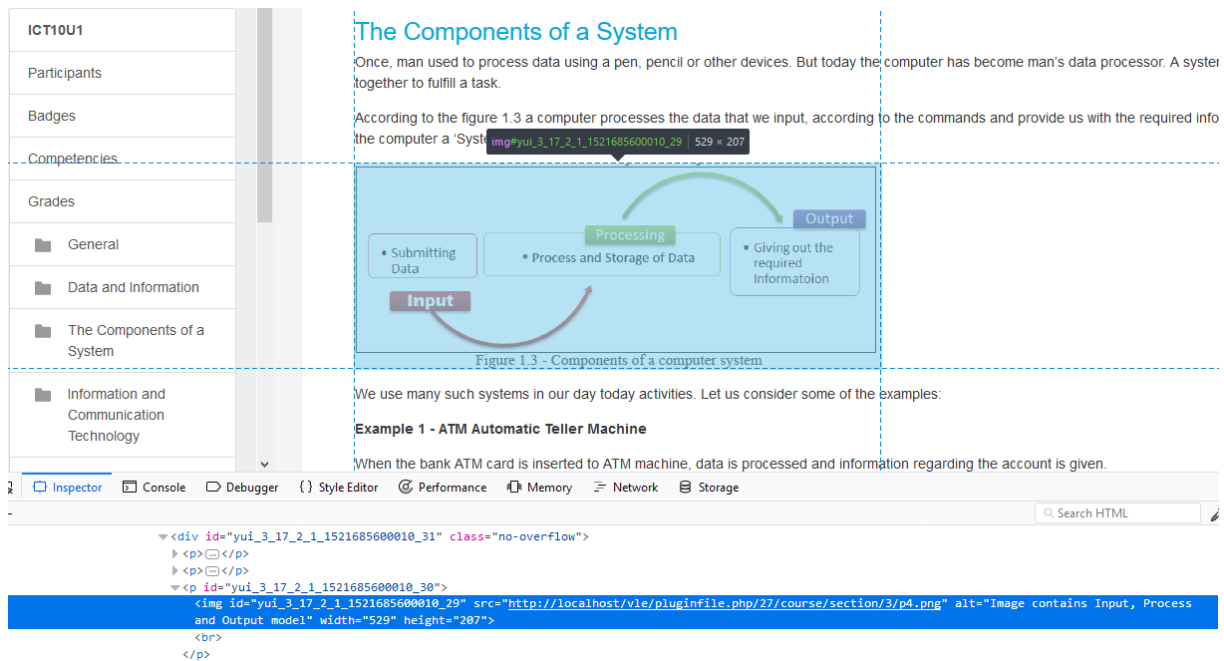


Figure 4.15 Code Inspect View of an Image before the Code Modification

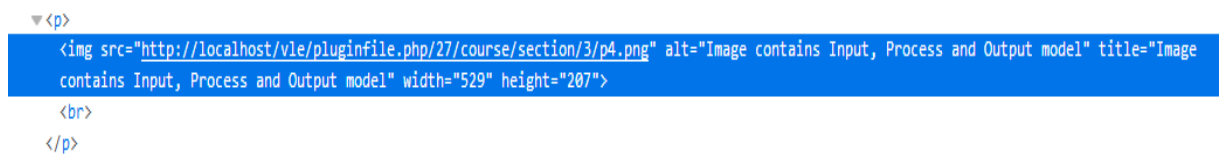


Figure 4.16 Code Inspect View of an Image after the Code Modification

You can note that Figure 4.15 does not contain “**title**” attribute in the “****” tag but in Figure 4.16 contain the “**title**” attribute and value after doing the code modification.

Next modification is done to provide the “**summary**” attribute for the table. Default Moodle implementation support entering a “**caption**” to a table during the time of creation. Aim of this modification is to grab the text provided for the “**<caption>**” tag and to embed it to the “**summary**” attribute in the “**<table>**” tag. It helps the screen readers to identify and read what is inside “**summary**” attribute and it can be provided to the blind users to get some clear idea on what is interpreted as a table before understanding the content of the table.

Like the modification did on “****” tag “**title**” attribute embedding, script is added to the “**script.js**” file to filter the tables and to check whether they have a caption specified. If so value available inside “**<caption>**” tag will be entered to the “**summary**” attribute value in “**<table>**” tag. Consider the following code written to handle that modification when rendering the page with tables.

```
// list all table
```

```

var tlist = document.getElementsByTagName("table");

//alert(tlist.length);

// removing tables which doesn't contain "<caption>" tag and setting "summary" attribute
for (var i = 0; i < tlist.length; i++)
{
    // getting the no. of rows and columns in the table

    var trows = tlist[i].rows.length;

    var tcols = tlist[i].rows[0].cells.length;

    // getting the column headers

    let tcolhead = [];

    for (var c = 0; c < tcols; c++)
    {
        tcolhead.push(tlist[i].rows[0].cells[c].innerHTML);
    }

    var chead = tcolhead.join(", ");

    //alert(trows);

    //alert(tcols);

    //alert(chead);

    if(tlist[i].caption.innerHTML.trim() != "" && tlist[i].caption.innerHTML.trim() != null)
    {
        //alert(tlist[i].caption.innerHTML);

        tlist[i].setAttribute('summary', tlist[i].caption.innerHTML.trim());

        // adding table info to summary

        var summary = tlist[i].getAttribute('summary').trim();

```



```

summary += ' This table has ' + trows + ' rows and ' + tcols + ' columns.';

summary += ' Column headings are ' + chead + ' ';

tlist[i].setAttribute('summary', summary);

}

}

```

More of the code is similar to the previous image title manipulation modification. Only difference in the above code block is “**table.caption.innerHTML**” method is called in order access the value given under “<caption>” tag. After checking whether value exists and then forwarded to set the value for the “**summary**” attribute. It is quite important to define summary for table because screen readers easily read what is inside summary.

For the blind users to figure out how many columns and rows exists in a specific table above script includes some code to get the count of rows and columns. In addition to that columns headers are loaded into a string with comma separator after each column heading and finally combine the detail string with the existing summary attribute value. Following Figure 4.17 and Figure 4.18 shows the code inspection view before and after the modification.

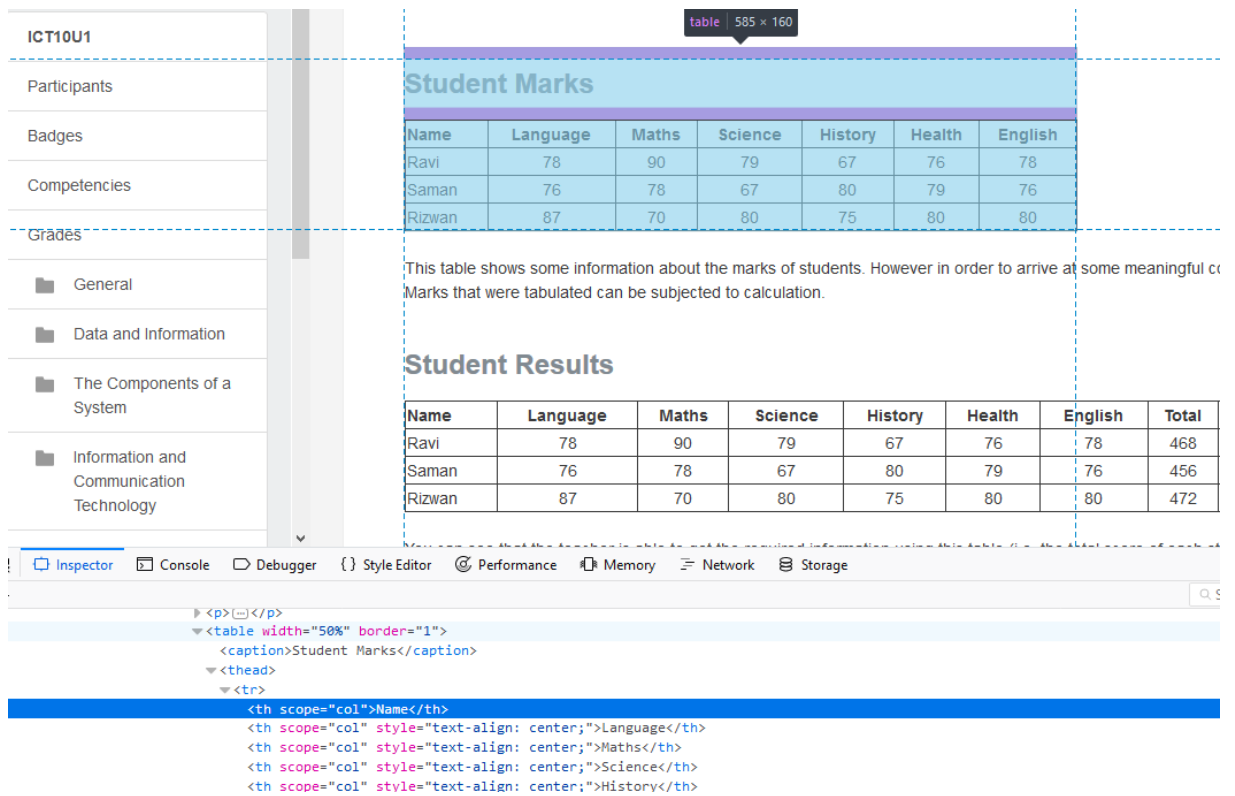


Figure 4.17 Code Inspect View of a Table before the Code Modification

```

<table summary="Student Marks. This table has 4 rows and 7 columns. Column headings are Name, Language, Maths, Science, History, Health, English."
width="50%" border="1">
  <caption>Student Marks</caption>
  <thead>
    <tr>
      <th scope="col">Name</th>
      <th scope="col" style="text-align: center;">Language</th>
      <th scope="col" style="text-align: center;">Maths</th>
      <th scope="col" style="text-align: center;">Science</th>
      <th scope="col" style="text-align: center;">History</th>
      <th scope="col" style="text-align: center;">Health</th>
      <th scope="col" style="text-align: center;">English</th>
    </tr>
  </thead>
</table>

```

Figure 4.18 Code Inspect View of a Table after the Code Modification

4.3 Content Creation

To perform a sound level of testing and evaluation on both tool and its content in the next chapter following content is added to the Moodle DB. As per the new implementation of user roles in Moodle infrastructure same user can behave differently in different context under different user roles. As an example a particular user can enroll as a Student in one segment and same user can be enrolled as a Teacher in some other segment. So for our case we work with one user only with one user role throughout the site without modifying the existing role assignment functionality. Following Comma Separated Values (CSV) file is used to add some users to the Moodle environment is denoted in Figure 4.19. Value for “**sysrole1**” is set as blank because users are assigned to course modules and their roles on those modules through the “**Site administration**” option given for Admin users.

username	password	firstname	lastname	email	sysrole1
padma	123qaz@ESOFT	Padma	Silva	padmasilva@gmail.com	
oshan	123qaz@NAIS	Oshan	De Silva	oshan89@yahoo.com	
dinath	123qaz@ESOFT	Dinath	Anjana	dinath_rox77@yahoo.com	

Figure 4.19 CSV File to Add New Users

Following Course categories were created to visualize the look and feel on the Moodle homepage is shown in Figure 4.20. And as a beginning course content was added to the Grade 10 Information Technology subject with relevant course activities like Assignments, Quizzes & Forum discussions. To check the accessibility against the content some text, images and tables kind of course context is added. Figure 4.21 shows the different types of content added on a sample Moodle course.

Course categories

- ▼ **Grade 10**
 - ▷ **Information Technology** (9)
 - ▷ **Mathematics** (32)
- ▼ **Grade 11**
 - ▷ **Information Technology** (6)
 - ▷ **Mathematics** (25)

Figure 4.20 Course Categories in Moodle Homepage

If you carefully note the below Figure 4.21 it contains a basic text paragraph, table with a caption, image with text, links for course activities like Forum Post, Quiz and Assignment.

Example 1

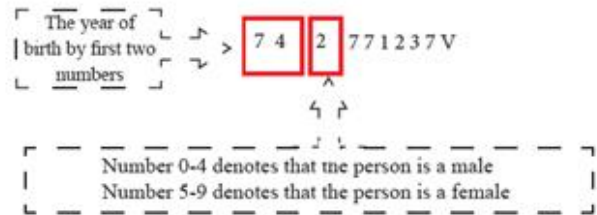
It will be difficult to get an idea about the subjects and marks if names and marks are written separately on term test results.

Ravi 78, 90, 79, 67, 76, 98 Rizwan 87, 70, 80, 75, 80, 80 Krishan 76, 78, 67, 80, 79, 76

But these names and marks can be tabulated as follows:

Student Marks

Name	Language	Maths	Science	History	Health	English
Ravi	78	90	79	67	76	78
Saman	76	78	67	80	79	76
Rizwan	87	70	80	75	80	80



[Discussion on Barcodes and ISBN](#)

[Write another example each for the characteristics of information](#)

[Provide more other examples for data and information](#)

[Quiz on Data and Information](#)

Figure 4.21 Sample Course Contents in Moodle Course

Following Figure 4.22 shows a Course role assignments were made to evaluate the accessibility of course context which are added against each user role on that context.

Full name	Information and Communication Technology
Short name	ICT10U1
ID number	
Category	Information Technology
Groupings	0
Groups	0
Role assignments	Student: 1 Blind Student: 1 Blind Teacher: 1
Enrolment methods	Manual enrolments
Format	Topics format
Sections	General Data and Information The Components of a System Information and Communication Technology Applications of Information and Communication Technology Demerits of ICT Evolution of the Computer Summary
Modules used	Assignment Forum Quiz

Figure 4.22 Assigned User Roles in a Moodle Course

Important tips required when using the developed system is separately attached in Appendix A: User Manual section in this thesis. Before putting the users on real use of the system appropriate level of training is given to both students and teachers in the school to understand the basic features and elements available in the Moodle environment. Few site demonstrations and training is conducted by engaging the students to provide some brief idea on how to become friendly with the various modules available in the Moodle screen. After putting them into use and make them familiar with the working procedure let them to provide the feedback on the platform and the functionalities and are documented in the following Evaluation chapter. Some modifications are made to the initial model which is developed based on their valuable thoughts and there were lot of positives which are identified while they are experiencing the system. But faced some challenges when providing them with the necessary level of training as the target crowd need some special attention while learning. But the support got from the staff of CSDB is unforgettable. Without their contribution this work will not become successful.

Chapter 5 : Evaluation

This chapter covers the testing and evaluating strategy of the built system including the test plan with strategy and test data to be used. It also includes the various test cases, results obtained, explanations & actions taken if any variations discovered during testing, debugging actions taken, various evaluation methods used, verification & validation methods used in each section are thoroughly explained in this section. Both testing and evaluation looks like similar but those two disciplines work in two different ways towards overall project success. That is why both testing and evaluation is equally important when achieving acceptable user-friendly product.

Conducting sound level of evaluation for any type of project is compulsory to ensure the appropriateness, correctness and the accuracy of the development. Conducting of basic level of testing only reduce the errors/bug of the system which is developed. But yet there may be some misalignments of the original scope or requirements of the project. So the evaluation helps you to conduct a deep level of study what we did was correct and accepted by the target audience. We can consider evaluation as a relevance of project achievements. And also the sustainability and the impact on the project users by the resulting software/system which is developed. It is far more towards a systematic approach than a basic study of outlined model.

5.1 Evaluation Approach

In this research project it use both Experiment based and Opinion & Interview based evaluation approaches. Because some parts of the research cannot be just evaluated with the basic Opinion & Interview based method. It only provide some level of feedback which can be useful for making further refinements to the functionalities in general. But it will not be enough to ensure the usability and accessibility. So Experiment based evaluation is useful to see the different level of experience gained by the users by the existing basic Moodle instance and the prepared customized solution specifically for the visually impaired students. That deep evaluation justify the impact and advantage over the existing Moodle basic model. In addition to that as the research is conducted based on mixed mode paradigm (both qualitative and quantitative research) using both Experiment based and Opinion & Interview based evaluation approaches will be required. Opinion & Interview based evaluation helps to justify the qualitative research methodology and Experiment based evaluation helps to justify the quantitative research methodology.

When conducting the evaluation first the visually impaired users got the opportunity to use the existing Moodle with basic interface features and one single sample learning context which has all sort of content including;

- Text
- Images
- Graphs
- Tables
- Hyperlinks.

Then one cycle of Interview and feedback is captured and documented. Then revised Moodle instance with new accessible context is given for experience. Then next Interview and feedback is captured. By comparing those to test/evaluation results further decisions are taken to realign the development based on those continuous feedback and opinions. Further checklist is prepared and maintained to ensure all features and points have taken into account before taking any further decisions. The accessibility standards which were identified during the research is then taken into consideration to prepare Experiment based evaluation. Because those accessibility standards are formed by the authoring bodies for the web and internet. So it was important to address those standards when it comes for web accessibility. It helped a lot to satisfy the point accessibility for disables means accessibility for all. Project development were be based on incremental development approach so the lessons learnt during continuous evaluation is considered for the next revisions made during later increments.

As our target audience will be students with vision problems conducting Interview & Opinion based evaluation is far more suitable but it will not be enough to take the final accounting to make sure the system which is developed is fully accessible in all sort of forms. So additionally Experiment based evaluation is helpful to gather the real user experience and the evaluation results can be used to finalize the achievements of the project.

In addition to the tool and content accessibility, when evaluating the system following standards are also considered. They are;

- WAI-ARIA (Accessible Rich Internet Applications)
- ATAG (Authoring Tool Accessibility Guidelines)
- WCAG (Web Content Accessibility Guidelines)
- UAAG (User Agent Accessibility Guidelines)
- Equality Act.

Following are the main areas which are considered during evaluation. During evaluation in each sections functionality and its content are considered. They are;

- Login Screen and Elements
- Main Navigation Menus
- Dashboard and News Items
- System Chat and Its Components
- Calendar Events
- Learning Context
 - o Text Data
 - o Image Data
 - o Table Data
 - o Audio / Video Data
 - o Embedded Files (Eg: PDF)
- Assessments
 - Assignments
 - o Quizzes
- Hyperlinks.

5.2 Evaluation Data Sets

Please note that there will be different time durations set for the visually impaired students during assessments and they require and granted additional time than sighted students during examinations in the manual method.

In the first go/dry run I introduced the ICT O/L subject content as sample learning context. So all materials are prepared accordingly. There are standard material for the sighted students and specially organized context for the visually impaired students. Sample content is prepared to cover all chapters in the government text books for year 10 and 11 students based on considering the evaluation criteria.

To check the knowledge related to O/L ICT MCQ questions (Paper I), sample online quiz was made and to check Writing paper questions (Paper II), sample assignment was prepared. To provide students a feedback separate customized feedback module has implemented. Results gathered during those assessments and user sessions is documented herewith to provide evidence of the acceptance of the system by the visually impaired students. To ensure the answers provided by the visually impaired students are accepted when preparing assessments

recent O/L ICT examination past papers were used. As I am engaged with academic field the knowledge and experience is used when preparing sample study materials and assessment feedback to the visually impaired students.

Above mentioned methods were carried out during evaluation process and results of the evaluation is used to make necessary adjustments for the misaligned features of the developed system. Initial evaluation is conducted by myself using a checklist to ensure all proposed features in the system are addressed with the given solution and then system will be hosted under the following sub domain to provide access to the visually impaired students as well as visually impaired teachers in the school.

<http://vle.csdeafblind.lk>

In addition to the feedback given after assessment by myself to the visually impaired students, gave the facility for the visually impaired teachers also provide their student specific feedback thorough the developed functionality. Then crosschecked those two versions of feedbacks to evaluate whether those two are same or if there any variation then it is considered as an input to make changes to the concept that we developed during research and what we developed.

5.3 Unit Testing & Sub System Testing

Initial evaluation begins with basic level of testing. There were several modifications did on the existing Moodle implementation. Following are the key areas where the modifications are made.

- Login Form
 - o All elements are attached with an access key
- Footer
 - o Script file is attached to generate list of;
 - Navigation Options
 - Buttons on a Page
- Assessments
 - o Quizzes
 - To provide a custom time limit for blind students
 - o Assignments
 - To provide a custom due date for blind students
- Events
 - o Assignment due dates notification for blind students with the Calendar module

- Content Rendering on 2D structures
 - o Image alternate text
 - o Table summary

In the meantime conducting above set of developments unit testing is conducted to ensure all modules are working as expected for both sighted students and blind students. Basic level of visual verification is made to ensure that all figures and dates are displaying accordingly. Because those modules are working already and put it into use after a solid testing process by the Moodle team. After checking each unit which is modified then conducted a cross reference validation to make sure the changes did on Assignment module is correctly reflect to the Calendar module. Because the due dates which are set will be displayed as an event on the Calendar component as the two modules are related with each other. After conducting several test attempts based on basic test cases prepared and ensured that all modules are functioning in the same way as earlier and are now ready to put it into real use by the visually impaired users to ensure whether primary aims and objectives are met.

Based on the above list a basic checklist is prepared to mark the state of the above functionalities and conclude that every functionality is working without any syntax errors. Logical errors are able to trap during the actual use and by the feedback given by the users of the final system. Our primary aim is to lift the accessibility of Moodle to cater for the needs of visually impaired students. So more time is spent on evaluating the system as explained in the evaluation approach.

5.4 Questionnaires

Following questionnaires are prepared in order to evaluate the system and the content which is developed during implementation process. Please refer the Appendix B: Questionnaires and Feedback Forms to get detailed idea about the structure of the questionnaires and the feedback forms which are prepared to get the feedback after using the default instance and instance with modifications of Moodle and associated ICT O/L ICT subject sample course content.

5.5 Evaluation Results and Feedback

First of all I have to state that getting the target population to use the system was not that much easy as expected. Because there were very few students expected to take participate for the O/L ICT course. Among them majority of the students are expecting to take the course in Sinhala medium. So to get the enough number of people to test the system I have used some

external users from my office work group and some of my friends which are not actually visually impaired but also contributed. The following Table 7 gives the count of users who are engaged with the testing and evaluation process.

Table 7: Users Participated for Testing and Evaluation

User Category	No. Of Users
Blind Students	10
Sighted Students	2
Blind Teachers	2
Developer	1
External Users	5

Interview & Opinion based evaluation is conducted when users are given the option of using the default Moodle instance without doing any modifications. Among the Blind Students community 10/10 says that it is very difficult to read and get the screen elements because the time taken to navigate through those options was very high. When they ask about the accessibility of the system what they returned is “The tool is bit accessible with the NVDA tool, but content is very difficult to read and understand”. So the next aim is to identify what areas that they mostly feel difficult to access and use. Their idea was News/Events, Calendar data, Course hierarchy, Online chat and Course contents are not accessible at all. So that evaluation confirms that default instance of Moodle is not accessible. Based on the Interview feedbacks the modified core of Moodle with sample course content is given to experience as the next revision.

Then the next level of evaluation is done based on the Experiment evaluation method. In that the newly modified Moodle instance is put it into practical use by the same above mentioned user population and the Questionnaires and Feedback forms as listed in Appendix B is given to the participants of the evaluation process. And the key areas proposed in evaluation plan is cross validated according to the criteria set in that checklist. The results gathered are then formulated based on the following Figure 5.1 and Table 8. It has been classified the results based on the followed cases as “Ok”, “Need Modifications”, “Not Ok”. That input is carefully analyzed when setting the final decision. As the results shows that most of the components in Moodle that was expected to make adjustments as far as concerning the accessibility in now met up to reasonable extent. Having the initial aim of making the Moodle tool and its content accessible, thus we can say that it is achieved its primary goal and objectives. Based on the

feedback some minor adjustments were made to make the solution more suitable to the target audience.

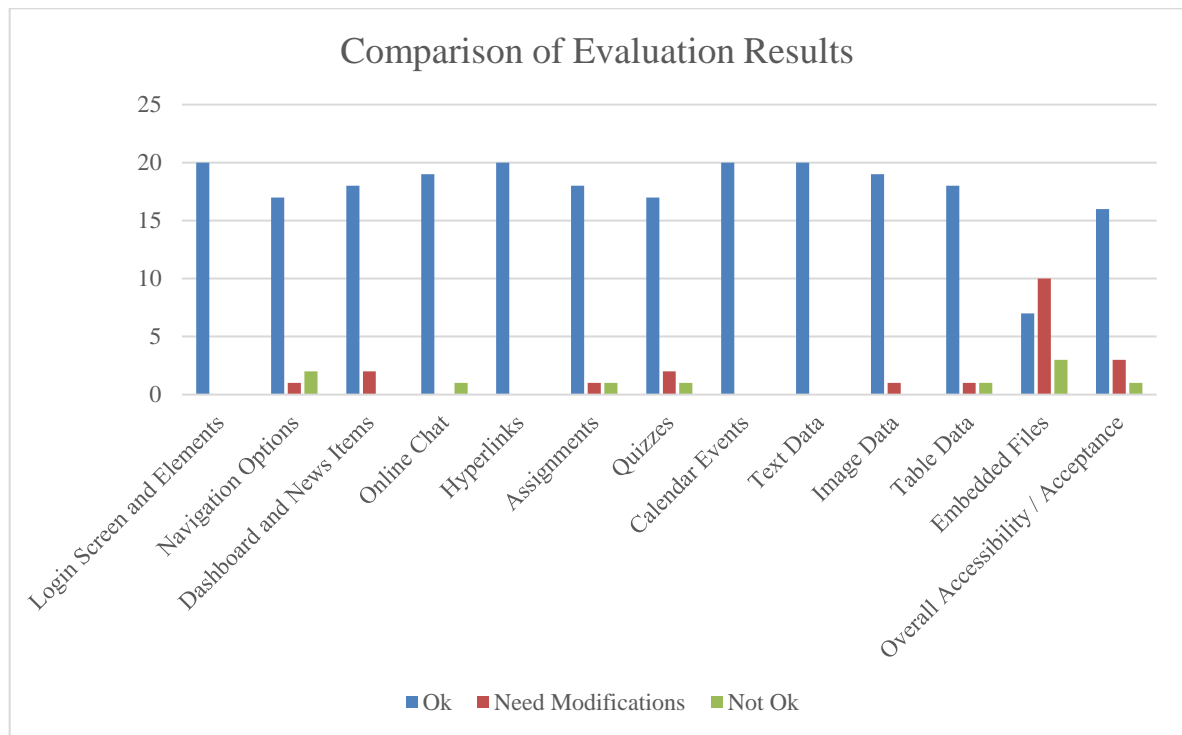


Figure 5.1 Comparison of Section wise Evaluation Results

The dataset which is used to generate the above figure will be shown in Table 8 as the below.

Table 8: Users Feedbacks for Implemented Sections

Section	Ok	Need Modifications	Not Ok
Login Screen and Elements	20	0	0
Navigation Options	17	1	2
Dashboard and News Items	18	2	0
Online Chat	19	0	1
Hyperlinks	20	0	0
Assignments	18	1	1
Quizzes	17	2	1
Calendar Events	20	0	0
Text Data	20	0	0
Image Data	19	1	0
Table Data	18	1	1
Embedded Files	7	10	3
Overall Accessibility / Acceptance	16	3	1

The marks gathered during quizzes by both sighted and blind students are then formulated based on the following Figure 5.2 and Table 9. It has been classified 5 sample quizzes results based on the followed cases as “Average Marks of Sighted Students” and “Average Marks of Blind Students”. Each quiz maximum marks is 10 and for the chart it is used the average marks of each category of users. This can be used to get the more statistical information related to the accessibility of the system. It also helps to evaluate the significance of the approach which is used by the implementation.

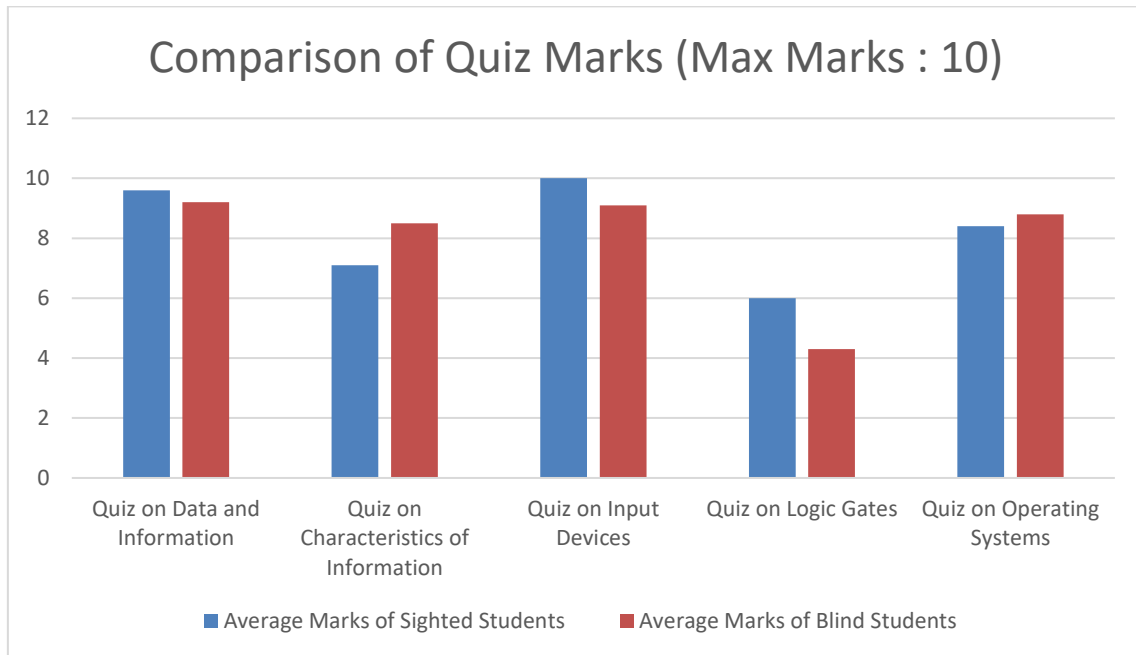


Figure 5.2 Comparison of Quiz Marks Based on User Type

The dataset which is used to generate the above figure will be shown in Table 9 as the below.

Table 9: Average Marks for Quizzes

Quiz Name	Average Marks (Out of 10)	
	Sighted Students	Blind Students
Quiz on Data and Information	9.6	9.2
Quiz on Characteristics of Information	7.1	8.5
Quiz on Input Devices	10.0	9.1
Quiz on Logic Gates	6.0	4.3
Quiz on Operating Systems	8.4	8.8

5.6 Final Results

Based on the evaluation conducted following set of final results were gained. As the primary aim it is set to make necessary adjustments to make Moodle 3.2 version compatible with the needs of visually impaired students and to convert the system into a proven accessible solution. During research we got to know that accessibility matters on both tool and its content. So the results obtained guarantees that both tool and its content is up to level of accessible than the earlier default instance that they got to experience. Based on the feedback that is obtained and discussed in the previous section we can assume that the effort put on developing a platform that is accessible to those visually impaired users came to a reality.

Lessons learnt after each successful evaluation cycle is fed as the input for the next revision made. After tuning the system based on the feedback makes the resulting system more and more accurate and accessible. But as we have a main limitation of less number of students expecting to take O/L ICT subjected selected, we were forced to use the same population over and over several attempts to evaluate the system.

Finally after conducting the evaluation we can see that the system and the content improved with accessibility according to the world standards. And we can assure that the research questions are addressed properly during the development and figures shows that majority of the crowd accept the final solution.

Chapter 6 : Conclusion

This chapter covers the lessons learnt by implementing a Learning Management System for Differently Able Students. Aims and objectives were compared against the actual achievements of the system and deviations on the actual goals are critically evaluated as a part of this chapter. Answers to the Research Questions and the challenges faced during development are also addressed in the below sections. Finally what sort of future work is going to perform also drafted in the following section of the thesis. It was a great opportunity to cater for the community based on what we learnt during our MSc program. As I personally engaged with academic field it was a real pleasure to do something valuable for the community of students. In the current context of education system created some gaps for visually impaired students while they are mixing with other sighted students. And the main reason which I targeted this sort of crowd is because usually visually impaired people will get less attention in the community when they get compared with a normal person once they put into the same set of skilled workers when they try to get an opportunity to be employed like all others.

6.1 Aims and Objectives Vs Actual Achievements

Aims and objectives of the proposed system is to develop a system for visually impaired e-Learning platform with full accessibility. Main aim of the solution is to build a methodology where visually disabled persons to get the similar usage and experience as normal students without any accessibility concerns. Based on the feedback of the students in the CSDB we can build a conclusion that the system which is developed is achieved its aims and objectives up to satisfactory level. Actual successful ratio of the resulting system can be obtained once the target crowd in the school get the results for O/L ICT subject by facing the O/L examination in 2019 December.

6.2 Evaluation Answers to Research Questions

The research which I conducted allows to find the answers for the following 3 main research questions and are critically evaluated in this section. Conducting a suitable level of research and literature review able to find answers for all the below research questions set during early stages of the project.

- 1) What are the issues related to IT education for visually impaired students in school curriculum in Sri Lanka?

Sometimes they won't get the printed textbooks on time. Even the technology is in place still there are less crowd participating for such courses because of the less support in the education infrastructure. There are not enough teaching staff in the school with necessary skills on the subject stream. Students are quite afraid to take part for such technical subject because of the lack of clear understanding on how useful taking this subject selected for their future. Even the government authorities are responsible to provide equal opportunities they are failed to do so.

2) What are the gaps, in related to visually impaired students over sighted students in current LMS features relates to the viewpoint of accessibility matters?

Main problem is to reading and understanding 2D content like images, tables, etc. Current Moodle implementation is not supporting content rendering for visually impaired users. Due to that content misalignments created some gaps related to accessibility. In general because of their primary defect they are not able to read videos, PDF files kind of attached content but sighted students are capable on understanding all those example types of contents.

Navigation is a key issue related to the current development and are now overcome with the functionality provided to get the list of Navigation Option and deciding where to navigate by the user requirement. Key elements of the screen is notified to the users. As an example all the buttons with their access keys will be notified to the users. So upfront they are aware on what sort of navigation options and buttons are in the currently working interface. It helps to improve the accessibility of screen and its elements into a greater stand.

3) How to enable 2D structures for Braille format using Moodle infrastructure?

Based on the features supported by screen readers, content is reorganized based on the tips provided by web governing authorities. Contents are made realign with the web accessibility standards. As there are some TTB converting tools are available at the moment our aim is to adjust content into a way that the screen readers are able to diagnose and cater accordingly. Once the required level of information is provided with those 2D structures and remaining work is handled by the existing tools and techniques available in the industry. As an example once alternate text is set into the images, for the visually impaired users can notify with the text description provided with the image. Similarly when considering tables like 2D content description is provided to the users with the numbers of rows and columns available in the table with the columns headers, users get to know something about the table before they

actually read the content and understand it. But there are some totally none avoidable circumstances like presenting the content of video files, etc.

6.3 Challenges and Deviations

Initial deviation occurs when narrowing down the scope to cover the solution to the visually impaired category of students because of the time limitation. Main challenge was Moodle installation. Because all the newer versions of Moodle requires all latest versions of PHP, MySQL, but the shared hosting plans does not give the freedom to modify/update the installed software versions according to our custom needs. They always suggest us to go with older Moodle release like version 1.9 or to upgrade the server into a dedicated server plan. But somehow by mixing the skills and software together able install and configure the Moodle 3.2 version to begin the development.

Then the next main challenge is to break the core Moodle architecture. As it is a stable product which is developed in a total different code architecture it was very time consuming to analyze the places in which the code must be modified. Even some situations caching put me into lot of trouble. Some situations same work is need to be repeated again and again to get the expected result. There were some times my mindset was complaining me about the decision which I took to select an existing tool like Moodle rather than developing something from the sketch. But Moodle core is carefully written pieces of code with minimal chances the implementation may go out from the decried functionality.

Even though the initial plan is to find alternative ways to display PDF file contents, but while continuing the development change the idea of looking into ways that a method of PDF file handling. Because in PDF files also what we get is again paragraphs, lists, headings, tables, images kind of mixed content. So the platform which is developed is capable of rendering those similar content in a way which is compatible to the visually impaired students, so there is no real harm of not developing such a mechanism to handle PDF files. The evaluation guarantees that the functionality which is developed is capable of giving the accessibility support for the needed audience.

When it comes for debugging it was a complicated process. Adding breakpoints on the coding sometimes didn't work in the expected manner. It is all because the different code framework that the Moodle developers use. To overcome problems encountered the support available also minimal, so I was required to build my own method of testing and debugging the code

during development time. Some considerable time required to build and test course categories, courses, course content and activities on top of those courses.

There are some untouched areas due to the time limitations and are able to cover them in the future when I get some chance. As the current systems with the basic features are functioning as expected manner didn't spend much time on converting everything. As an example there are some quiz types with drag and drop answers also. As they are too complicated for the visually impaired students, necessary instructions are given for the authorized bodies who are creating such quizzes and contents. There were some challenges while preparing questionnaires and translating the feedback got by the visually impaired students. Even getting the enough number of crowd to test the system was not as easy as thought. Because the students in the school who are participating to the subject even preferred to take the course in Sinhala medium.

6.4 Future Work

The research which I conducted allows me to see those gaps and the resulting system is some far able to minimize those gaps faced by visually impaired students. Willing to carry on the same research which I conducted for the MSc program for my further higher studies as well. Future plan is to continue the project while adding some more potential features as and when they discovered. Some other disability areas are removed due to the time constraint and expecting to take those features into account in the future. Expecting to merge those features once they are developed based on the importance to the society. Even though the product was mainly targeted the Blind Students in Ceylon School for the Deaf and Blind school, more interested on continuing the project with other parties who are interested on this area to give the real benefit to the society.

The second stage of this project is to make the system ready for the Deaf Students in the school by doing necessary adjustments. As the system is compatible with accessibility standards only few modifications are required to cover the Deaf Student community in the school.

As CSDB is not only the only organization that cater for differently able students, personally I believe that as I worked on an Open Source product the final solution can be make available for the researchers and parties who are working in the similar domain for reference and further improvements. Finally I take this as an opportunity to thank all the people who supported me in various way to make this project successful.

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Appendix A: User Manual

This section describe the important tips that you must aware how to use the system. Current system is web based so your device which is going to access this system must have a web browser installed (Eg: Mozilla Firefox, Google Chrome or Internet Explorer). Apart from that you device must have NVDA screen reader software installed. By default Insert Key is referred as NVDA Key. We encourage users to use any Windows operating system.

Most of the options are using Access Keys so please pick your option based on the following list.

Web Browsers and Access Keys

- If you are using Internet Explorer; Press Alt Key + access key
- If you are using Google Chrome; Press Alt Key + access key
- If you are using Mozilla Firefox; Press Alt Key + Shift Key + access key
- If you are using Opera; Press Alt Key + access key
- If you are using Safari; Press Alt Key + access key

Prerequisites to Access the System

- Web Browser
- NVDA tool
- Speakers or Headset

How to Access the System?

- Press Windows Key + R from the keyboard
- Type <http://vle.csdeafblind.lk>
- Press Enter Key

How to Login to the System?

- Press the access key “l” to go to login page
- Press the access key “u” to jump to user name textbox
- Press the access key “p” to jump to password textbox
- Press the access key “r” to on the remember user name option
- Press the access key “l” to jump to login button
- Press Enter Key

How to Navigate through the System?

Anytime to get a list of navigation options; Press access key “n”. You can jump between list options using TAB Key.

How to get Buttons in the Page?

Anytime to get a list of buttons on a page; Press access key “b”. You can jump between list options using TAB Key.

How to use NVDA Shortcuts?

- Make sure that Num Lock is off.
- Remember that screen reader users typically do not use a mouse. As you become more comfortable with NVDA, try using only the keyboard.

Reading

- Press Numpad Plus Key to read from the top of the page
- Press Ctrl Key to stop reading
- Press Numpad 8 to read current line
- Press Numpad 7 to read previous line
- Press Numpad 9 to read next line
- Press NVDA Key + Ctrl + Up or Down arrow key to increase or decrease rate of speech

Quick Navigation Keys

- H: Key for Headings
- F: Key for Forms
- T: Key for Tables
- B: Key for Buttons
- L: Key for Lists
- I: Key for List Items
- F6: Browser Address Bar

- GOOD LUCK!!! -

Appendix B: Questionnaires and Feedback Forms

<u>Questionnaire on VLE</u>	
1	Can you easily access your VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
2	Can you easily login to your account in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
3	Can you easily access your O/L ICT course in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
4	Can you easily access your O/L ICT course chapter contents in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
5	Can you easily navigate into different sections in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
6	Can you easily access/understand table data in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
7	Can you easily access/read images in your VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
8	Can you easily chat with your colleague in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
9	Can you easily access your calendar events in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
10	Can you easily access news published on VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
11	Can you easily access a quiz in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
12	Does the time to complete a quiz is enough?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
13	Can you easily access an assignment in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
14	Does the time to complete an assignment is enough?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
15	Can you easily access grades and feedbacks given for assessments in VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>

- THANK YOU!!! -

Following feedback form is prepared to provide feedback on each question in the above questionnaire and documented as an input for next revision.

<u>Feedback on Questionnaire</u>	
1	
2	
3	
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12	
13	
14	
15	

<u>Feedback on VLE</u>	
1	Is your VLE Accessible?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
2	Is your VLE User-friendly?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
3	Is your VLE Easy to use?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
4	Is your VLE Available all the time when you want to use it?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
5	Are you Happy about the VLE?
	Yes <input type="checkbox"/> No <input type="checkbox"/>
6	Your Comments

- THANK YOU!!! -

Appendix C: Moodle Database Structure

This section includes the Moodle existing database structure if the tables which is modified during the implementation. Note that it only display the most important details related to table structure field names, data types, default values and etc.

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra
<input type="checkbox"/>	1 id 🔑	bigint(10)			No	None		AUTO_INCREMENT
<input type="checkbox"/>	2 course 🗑️	bigint(10)			No	0		
<input type="checkbox"/>	3 name	varchar(255)	utf8_unicode_ci		No			
<input type="checkbox"/>	4 intro	longtext	utf8_unicode_ci		No	None		
<input type="checkbox"/>	5 introformat	smallint(4)			No	0		
<input type="checkbox"/>	6 alwaysshowdescription	tinyint(2)			No	0		
<input type="checkbox"/>	7 nosubmissions	tinyint(2)			No	0		
<input type="checkbox"/>	8 submissiondrafts	tinyint(2)			No	0		
<input type="checkbox"/>	9 sendnotifications	tinyint(2)			No	0		
<input type="checkbox"/>	10 sendlatenotifications	tinyint(2)			No	0		
<input type="checkbox"/>	11 duedate	bigint(10)			No	0		
<input type="checkbox"/>	12 duedate1	bigint(10)			No	0		
<input type="checkbox"/>	13 allowsubmissionsfromdate	bigint(10)			No	0		
<input type="checkbox"/>	14 grade	bigint(10)			No	0		
<input type="checkbox"/>	15 timemodified	bigint(10)			No	0		
<input type="checkbox"/>	16 requiresubmissionstatement	tinyint(2)			No	0		
<input type="checkbox"/>	17 completionsubmit	tinyint(2)			No	0		
<input type="checkbox"/>	18 cutoffdate	bigint(10)			No	0		
<input type="checkbox"/>	19 teamsubmission	tinyint(2)			No	0		
<input type="checkbox"/>	20 requireallteammemberssubmit	tinyint(2)			No	0		
<input type="checkbox"/>	21 teamsubmissiongroupingid 🗑️	bigint(10)			No	0		
<input type="checkbox"/>	22 blindmarking	tinyint(2)			No	0		
<input type="checkbox"/>	23 revealidentities	tinyint(2)			No	0		
<input type="checkbox"/>	24 attemptreopenmethod	varchar(10)	utf8_unicode_ci		No	none		
<input type="checkbox"/>	25 maxattempts	mediumint(6)			No	-1		
<input type="checkbox"/>	26 markingworkflow	tinyint(2)			No	0		
<input type="checkbox"/>	27 markingallocation	tinyint(2)			No	0		
<input type="checkbox"/>	28 sendstudentnotifications	tinyint(2)			No	1		
<input type="checkbox"/>	29 preventssubmissionnotingroup	tinyint(2)			No	0		

Figure C.1 mdl_assign Table Structure

#12 “**duedate1**” is newly added to “**mdl_assign**” table to implement custom functionality.

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra
<input type="checkbox"/>	1 id 🔑	bigint(10)			No	None		AUTO_INCREMENT
<input type="checkbox"/>	2 name 🗑️	varchar(255)	utf8_unicode_ci		No			
<input type="checkbox"/>	3 value	longtext	utf8_unicode_ci		No	None		

Figure C.2 mdl_config Table Structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra
<input type="checkbox"/>	1	id 🔑			bigint(10)	No	None	AUTO_INCREMENT
<input type="checkbox"/>	2	name			longtext	utf8_unicode_ci	No	None
<input type="checkbox"/>	3	description			longtext	utf8_unicode_ci	No	None
<input type="checkbox"/>	4	format			smallint(4)	No	0	
<input type="checkbox"/>	5	courseid 🔑			bigint(10)	No	0	
<input type="checkbox"/>	6	groupid 🔑			bigint(10)	No	0	
<input type="checkbox"/>	7	userid 🔑			bigint(10)	No	0	
<input type="checkbox"/>	8	repeatid			bigint(10)	No	0	
<input type="checkbox"/>	9	modulename			varchar(20)	utf8_unicode_ci	No	
<input type="checkbox"/>	10	instance			bigint(10)	No	0	
<input type="checkbox"/>	11	eventtype			varchar(20)	utf8_unicode_ci	No	
<input type="checkbox"/>	12	timestart 🔑			bigint(10)	No	0	
<input type="checkbox"/>	13	timestart1 🔑			bigint(10)	No	0	
<input type="checkbox"/>	14	timeduration 🔑			bigint(10)	No	0	
<input type="checkbox"/>	15	visible 🔑			smallint(4)	No	1	
<input type="checkbox"/>	16	uuid			varchar(255)	utf8_unicode_ci	No	
<input type="checkbox"/>	17	sequence			bigint(10)	No	1	
<input type="checkbox"/>	18	timemodified			bigint(10)	No	0	
<input type="checkbox"/>	19	subscriptionid			bigint(10)	Yes	NULL	

Figure C.3 mdl_event Table Structure

#13 “timestart1” is newly added to “mdl_event” table to implement custom functionality.

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra
<input type="checkbox"/>	1	id 🔑			bigint(10)	No	None	AUTO_INCREMENT
<input type="checkbox"/>	2	name			varchar(255)	utf8_unicode_ci	No	
<input type="checkbox"/>	3	shortname 🔑			varchar(100)	utf8_unicode_ci	Unicode, case-insensitive	
<input type="checkbox"/>	4	description			longtext	utf8_unicode_ci	No	None
<input type="checkbox"/>	5	sortorder 🔑			bigint(10)	No	0	
<input type="checkbox"/>	6	archetype			varchar(30)	utf8_unicode_ci	No	

Figure C.4 mdl_roles Table Structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra
<input type="checkbox"/>	1 id 🗝️	bigint(10)			No	None		AUTO_INCREMENT
<input type="checkbox"/>	2 course 🗝️	bigint(10)			No	0		
<input type="checkbox"/>	3 name	varchar(255)	utf8_unicode_ci		No			
<input type="checkbox"/>	4 intro	longtext	utf8_unicode_ci		No	None		
<input type="checkbox"/>	5 introformat	smallint(4)			No	0		
<input type="checkbox"/>	6 timeopen	bigint(10)			No	0		
<input type="checkbox"/>	7 timeclose	bigint(10)			No	0		
<input type="checkbox"/>	8 timelimit	bigint(10)			No	0		
<input type="checkbox"/>	9 timelimit1	bigint(10)			No	0		
<input type="checkbox"/>	10 overduehandling	varchar(16)	utf8_unicode_ci		No	autoabandon		
<input type="checkbox"/>	11 graceperiod	bigint(10)			No	0		
<input type="checkbox"/>	12 preferredbehaviour	varchar(32)	utf8_unicode_ci		No			
<input type="checkbox"/>	13 canredoquestions	smallint(4)			No	0		
<input type="checkbox"/>	14 attempts	mediumint(6)			No	0		
<input type="checkbox"/>	15 attemptonlast	smallint(4)			No	0		
<input type="checkbox"/>	16 grademethod	smallint(4)			No	1		
<input type="checkbox"/>	17 decimalpoints	smallint(4)			No	2		
<input type="checkbox"/>	18 questiondecimalpoints	smallint(4)			No	-1		
<input type="checkbox"/>	19 reviewattempt	mediumint(6)			No	0		
<input type="checkbox"/>	20 reviewcorrectness	mediumint(6)			No	0		
<input type="checkbox"/>	21 reviewmarks	mediumint(6)			No	0		
<input type="checkbox"/>	22 reviewspecificfeedback	mediumint(6)			No	0		
<input type="checkbox"/>	23 reviewgeneralfeedback	mediumint(6)			No	0		
<input type="checkbox"/>	24 reviewrightanswer	mediumint(6)			No	0		
<input type="checkbox"/>	25 reviewoverallfeedback	mediumint(6)			No	0		
<input type="checkbox"/>	26 questionsperpage	bigint(10)			No	0		
<input type="checkbox"/>	27 navmethod	varchar(16)	utf8_unicode_ci		No	free		
<input type="checkbox"/>	28 shuffleanswers	smallint(4)			No	0		
<input type="checkbox"/>	29 sumgrades	decimal(10,5)			No	0.00000		
<input type="checkbox"/>	30 grade	decimal(10,5)			No	0.00000		
<input type="checkbox"/>	31 timecreated	bigint(10)			No	0		
<input type="checkbox"/>	32 timemodified	bigint(10)			No	0		
<input type="checkbox"/>	33 password	varchar(255)	utf8_unicode_ci		No			
<input type="checkbox"/>	34 subnet	varchar(255)	utf8_unicode_ci		No			
<input type="checkbox"/>	35 browsersecurity	varchar(32)	utf8_unicode_ci		No			
<input type="checkbox"/>	36 delay1	bigint(10)			No	0		
<input type="checkbox"/>	37 delay2	bigint(10)			No	0		
<input type="checkbox"/>	38 showuserpicture	smallint(4)			No	0		
<input type="checkbox"/>	39 showblocks	smallint(4)			No	0		
<input type="checkbox"/>	40 completionattemptsexhausted	tinyint(1)			Yes	0		
<input type="checkbox"/>	41 completionpass	tinyint(1)			Yes	0		
<input type="checkbox"/>	42 allowofflineattempts	tinyint(1)			Yes	0		

Figure C.5 mdl_quiz Table Structure

#9 “**timelimit1**” is newly added to “**mdl_quiz**” table to implement custom functionality.