## A comparative Study of D2L's Performance with a Purpose Built

# E-learning User Interface

## For Visual- And Hearing-Impaired Students

by

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science (MSc) in Computational Sciences

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## Abstract

An e-learning system in an academic setting is an efficient tool for all students especially for students with physical impairments. This thesis discusses an e-learning system through the design and development of an e-learning user interface for students with visual- and hearing- impairment. In this thesis the tools and features in the user interface required to make the learning process easy and effective for students with such disabilities have been presented. Further, an integration framework is proposed to integrate the new tools and features into the existing e-learning system Desire-To-Learn (D2L). The tools and features added to the user interface were tested by the selected participants with visually-and hearing- impaired students from Laurentian University's population. Two questionnaires were filled out to assess the usability methods for both the D2L e-learning user interface at Laurentian University and the new e-learning user interface designed for students with visual and hearing impairment. After collecting and analyzing the data, the results from different usability factors such as effectiveness, ease of use, and accessibility showed that the participants were not completely satisfied with the existing D2L e-learning system, but were satisfied with the proposed new user interface. Based on the new interface, the results showed also that the tools and features proposed for students with visual and hearing impairment can be integrated into the existing D2L e-learning system.

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## Chapter 1

# Introduction

This chapter includes an initial perception of e-learning system by students with special needs and a clarification of scope of the problems they face. It also explains the purpose of the study, how we conducted this study, and its limitations.

### 1. Background

The Canadian academic services sector continues to be subjected to ever-increasing academic needs and a rapidly changing environment. For special needs students, this translates to uncertainty and concern about the future and how it will affect their learning in unpredictable need to be addressed. In the global educational technology sector new technology has enhanced the efficiency of learning delivery through the electronic Learning Management Systems (LMS) and technology tools for teaching such as Course Management Systems and smart technologies. The increased use of educational technology tools and its associated interconnectivity from local area networks through intra-nets, the Internet and now extra-nets of academic organizations has increased the capability for individuals and groups to exchange information virtually.

The rapid development in the e-learning technology has enabled special needs students to overcome their learning barriers and make progress in their learning endeavors. Educational technology has the potential to facilitate the inclusion of special needs students in classrooms of higher learning. When pursuing this subject, a diverse range of special needs students' issues, both technical and non-technical, needs to be considered. Some studies [5, 10, 45, and 52] show that most of the technical issues with e-learning systems reported by the special needs students remain unresolved. Accordingly, educational organizations at all levels also invest large amounts of time

and resources in educational technology, with the goal of enhancing the educational effectiveness of the learning environment [57]. In the educational technology context, it has been found that there is a high success rate from an e-learning approach among learners of all ages [42, 62]. This resulted in a sense of increased confidence, pride among learners and increased educational options available to them. In addition to that, surveyed participants demonstrated an increase in personal skills; namely, time management, computer literacy, independence and work ethic [62, 72]. Also, e-learning provides students with access to qualified and specialized instructors. If instructors were technologically literate, the rate of student success would only increase [72].

### 1.1 Statement of the Problem and Scope

Introducing the Canadian e-learning systems as a way to dispense knowledge has linked technology and human experts together, facilitated universities and reduced the costs of delivering academic activities. Because of this, the Canadian e-learning systems should affect positively all students whether they have special needs or not. Moving in this direction, with the update of e-learning systems in support of special needs students, some of the students' issues have not been completely resolved. As an example, Canadian e-learning systems may require more time, effort, and adaptive technologies, suggesting that students with special needs have a long way to go to be equal with other students in the same educational technology environment that use e-learning materials. However, the engagement of educational material, teachers and special needs students during the expansion of e-learning system infrastructure has received much less attention. On the other hand, providing the Canadian universities with an e-learning system alone for normal students is not always enough. Instead, an e-learning system must be linked to or integrated with other special needs software and infrastructures that can respond to the future directions and merge the requirements of all students (with special needs or without) in the same e-learning environment. This thesis proposes the integration of the available technology for special needs students with the existing e-learning environment by developing an e-learning user interface of the integration development environment (IDE) that will enable students with special needs to use the same Learning Management System (LMS) as normal students. User study and testing needs to address the following questions regarding the design of the user interface for the students with special needs in the e-learning system.

- What does a special needs student expect from the existing e-learning system? Do these expectations differ from the new e-learning system user interface?
- Does the measure of usability testing based on the existing e-learning system differ from the new e-learning system user interface?
- Is it applicable to integrate the tools and features for special needs students with the existing e-learning environment?

## 1.2 Purpose of the Study

Most students with disabilities or without want to be able to attend their class, but they often miss their classes, miss parts of a lecture or are completely unable to attend their lectures. Enabling students to do this online by utilizing the existing technology is one way to increase opportunities for the participation of students with or without disabilities. That means there is a need to integrate and utilize these technologies according to students' needs to help in their learning ability and to encourage them to participate more in their academic goals. As a result, involving special needs students in the existing e-learning systems will simplify their learning process, increase their capability and utilize the available resources in the best way. Additionally, the adoption of this technology will enhance the effectiveness of the university system in delivery education to students with disabilities in an effective manner. The purpose of this study is to integrate the tools for students with visual or hearing impairment into the same e-learning system in the university without using any assistive software to improve their academic goals. The special tools in the user interface will enable students with visual and hearing impairment to interact within the environment of e-learning system as their peers do who do not have disabilities.

#### **1.3 Study Approach**

To achieve the purpose of the study it is broken into two parts: theoretical and practical.

**Theoretical:** First, the barriers and obstacles that special needs students experience in their academic life are explored. Second, the existing technologies should be adapted to facilitate the learning process within e-learning management systems are explored. For the purpose, following steps were taken.

- 1. Reviewing the current status of the literature.
  - 1.1 Research and review the barriers and obstacles to special needs students.
  - 1.2 Explore the existing technology and the e-learning software systems that should be integrated to help special needs students.

**Practical:** Design and develop e-learning user interface that merges the tools for special needs students with the existing system. The following steps were taken:

- The existing technology features such as command voice, button voice, button sign language and streaming media were employed to serve visually- and hearing- impaired students in the proposed e-learning interface and architecture.
- 2. Test the user interface and the architecture in the e-learning system. The testing consisted of a semi-structured interview to gather special needs students' expectations and also a survey was distributed to the visually- and -hearing impaired students.

3. Propose and design the e-leaning user interface by utilizing the information that has been collected from the literature and the respondent's perspectives, to allow efficient e-learning user interface. As well, to try to achieve the main purpose of this study, this is to improve the usability of the e-learning system by special needs students.

### 1.4 Limitations of the Study

The limitations of the study arise from human restrictions, resource constraints and methodological issues. The greatest limitation was related to human contact with special needs students. This required specialized persons to use sign language and other methods to avoid negative emotional aspects, as well as limitations related to the fluctuation of disabilities between students' and their ability to react or contact. Another limitation of this study is that it sampled only students identified at having special needs within Laurentian university. In addition, most of these students have not had a regular academic classroom, which required reaching them based on their location, time and ability. In the resource area, the greatest limitation is the lack of an e-learning system that can help them, because the existing system does not support the required technology. As a result, several technological barriers were noted throughout the study. The barriers were classified into the following three broad categories (a) access to the university e-learning systems by those students, (b) Lack of assistive technology in the university labs, (c) lack of streaming technology required for this type of research. In the methodology, sample size and the number of students of analysis were also limited. It was difficult to find significant relationships from the data that had been collected.

As a result t-tests are used as a statistical test for a small sample size to answer study questions. Lack of data limited the scope of the study analysis; the size of sample is a significant challenge in using different statistical tests. Due to these limitations the following ideas could be considered to add to the study on e-learning for special needs students:

- Reproduce the study with a greater sample size and with a broader geographic region.
- Reproduce the study with the e-learning system that allows a solution to the above technological barriers.
- Reproduce the study with students receiving a complete service under *Individuals with Disabilities Education Improvement* from the special needs office at their universities.

## **1.4 Outline of the thesis**

Chapter 2 is a review of the e-learning systems for special needs students and the most important barriers that they face in an e-learning system. As well the assistive technology is reviewed for two types of special needs students: visual and hearing impaired students. Chapter 3 discusses the prototype design for the user interface, and methods of data gathering to design an e-learning user interface that meets the needs of students with visual and hearing impairment. Chapter 4 discusses the implementation of the selected design for the E-learning User Interface and the tools for students with visual and hearing impairment. Streaming technology that can be integrated within the e-learning system is discussed. The e- learning system architecture is also presented in this chapter. In chapter 5, a statistical method is presented that is used to analyze the data that was collected from questionnaires in an attempt to test the usability factors for the eLearning user interface designed and to compare it to the D2L e-learning system at Laurentian University. The results obtained are analyzed and discussed in this chapter. Chapter 6 summarises the research and suggests some recommendations for the design of an e-learning system for students with special needs. In addition, future research is discussed to expand the knowledge about special needs students and the e-learning systems.

# Chapter 2

# Review of the Literature

This chapter presents a literature review of e-learning systems for special needs students and the most important barriers that are faced by them in the e-learning system. In addition, assistive technology is reviewed for three types of special needs students: visually impaired, hearing impaired and mobility impaired students.

#### 2.1 E-learning for Special Needs Students

In Canadian universities, special needs students use the e-learning system for the courses offered through regular LMS that does not contain tools for special needs students. While this has not been applied by all Canadian universities, lack of interest in special needs e-learning systems has been recognized, which includes lack of specialized people in Web design accessibility, resources, special needs materials, and poor training techniques which make special needs students not interested in e-learning systems. However, special needs students only need to obtain the right special assertive technology to support their needs in order to replace the inaccessible information on websites [8]. To address many kinds of special needs types can require different and special strategies. For this reason, in this study we will focus our attention on Web accessibility for those with special needs. This means that everyone including those with special needs have equal access to university e-learning system, thereby ensuring the students ability to "perceive, understand, navigate, and interact with the Web" [34].

However, current literature explores e-learning systems from normal student's perspective with little focus on students who required special needs technology that is used in these systems. All special needs students should be considered when designing e-learning applications by proposing principles for designers developing e-learning applications in order to simplify interaction for special needs students or teachers [49]. These principles should also concentrate upon students who have no special needs. This study shall therefore offer a different approach in that it particularly targets the use of e-learning among all students in Canadian universities within an integrated development environment (IDE). IDE and e-learning tools are useful in the e-learning environment where knowledge and equality are gathered cooperatively. Finally, this study will focus on the web accessibility and usability of e-learning systems for special needs students by integrating the tools in the same collaborative environment used for other students.

#### 2.1.1 Visually Impaired Barriers

According to the Royal National Institute for the Blind "the internet is one of the most significant communication developments since the invention of Braille. For the first time ever, many blind and partially sighted people have access to the same wealth of information as sighted people and on the same terms" [66]. Because of that, the practices of blind or low vision students while using the internet and e-learning systems have transformed over the years for a variety of reasons. Firstly, in the research literature, of all the different special needs scenarios, blind users show the most complications when performing a task [14, 38, 48, and 61]. Secondly, the growing use of LMS in all aspects of teaching and learning process by increasing presence of adaptive e-learning systems in Canadian universities. Thirdly, increase in the use of computer based evaluating methods, testing materials, and grading systems. Finally, the vital role that is produced from these technologies is facilitating their life on one side and the increasing compatibility of e-learning with general-use information technologies on the other side. Nevertheless, Gerber [28] assured that blind or low vision people are willing to accommodate with frustration, high costs, deficient technology, and an extra amount of time because of the benefits of being able to be self-sufficient up to a point. Accordingly, the frustrations can be minimized by following good design

principles, such as the guidelines and protocols of the Web Accessibility Initiative (WAI) that support the evolution of the World Wide Web (www) and ensure its interoperability which works with universities to develop strategies, procedures, and resources to help make web accessible to students with disabilities [20]. However, regardless of significant research focus in this field, interacting with a virtual learning environment and using e-learning objects is still hard for a blind student who cannot see the screen and is unable to use a mouse [10]. Furthermore, interaction requires a new innovation that aids the smart technology and decreases another degree of software complexity.

All blind or low vision barriers should be considered when designing e-learning applications and courses management systems. In this section we will try to describe most barriers that are faced by blind and low vision students in their regular academic life. Fichten. [24, 23] have presented the barriers of students with low vision and who were blind. Two studies have been evaluated based on the accessibility of e-learning materials, other information, computer and communication technologies for 143 Canadian colleges and universities. As a result, their studies offered future vision to enhancing access, creating new e- learning approaches, and eliminating barriers. The studies showed that the available e-learning systems are not especially well designed to meet their needs in different situations such as when seeking help associated with materials and e-learning technologies at school, or when trying to access the systems, and when their instructors use e-learning resources. In addition, the students experience problems related to certain e-learning web sites and course management systems. For example, the students remarked on the inaccessibility of courses materials, specifically those in PDF. The problem with PDF is its incompatibility and its accessibility depends on how it was made. For example, documents with multiple columns, or tables and figures, when converted to a PDF file can generate reading problems because of the way screen readers interpret PDFs. Evans and Douglas[18] indicated also that the blind learners took extra time as long as the sighted learners on the learning performance

task. In terms of the extra time taken, the literature also shows that those learners who use adaptive technology generally take longer than others to complete the same online tasks [14]. Inflexible time limits to finish tasks that are built into e-learning testing components of course management systems was also a problem for both blind and low vision learners, a finding also noted by researches such as Kamei- Hannan [41] and Harding [31].

Problems with course-management systems include lack of audios, online interaction with teachers or facility that did not work with a screen reader, usability issues and also the incompatibility between LMS and the course management systems. In a preliminary survey [49], blind and low vision users assured that they preferred listening to a document in form of audio with a personal mp3 player, instead of reading it by a screen reader or a magnifier on a computer. On the other hand, blind users who did not use computers often identified social causes as barriers such as availability and accessibility of equipment and availability of training [18]. Fichten [23] also indicated that the main problem is lack of adaptive computer technologies, this lead to inadequate knowledge about how to use e-learning systems and materials effectively. Finally, most previous studies evaluated the similarities and differences of the problems students with visual impairments experience with e-learning materials. Table 1 summarizes the most important barriers of e-learning system noted by the blind and low vision students.

#### 2.1.2 Hearing Impaired Barriers

In the case of e-learning systems environment for deaf learners, it is not easy for developers to agree on if deaf students are deteriorating their normal academic activities because of incapability to deal with the audio/ video sound content issue. In addition, because of language and literacy capabilities there are obstacles to accessing commands in text-rich elearning systems. As well as, most of the literature shows that no information is presented on how many deaf education programs offer e-learning systems, nor what course management systems or LMS is available to

deaf students via e-learning. There is a need to offer e-learning education opportunities for deaf students by preparing future teachers [6]. On the other hand, we can't ignore the weak level of deaf students' achievements, this point to methods of teaching often used by mathematics teachers that tend to delay their understanding of mathematical concepts and perception of the learning environment [44]. This problem is even much more intense in special schools and especially among the hearing impaired students, because of their hearing disabilities [43, 55].

Therefore, there is a need for universities to create motivating e-learning systems integrated development environment with rich visual shows that are fascinating and engaging deaf students. Deaf and Hard of Hearing (DHH) College tried to study the effects of e-Learning systems and courseware as an educational tool on college deaf students to enhance classroom teaching but they found that this required more experimentation technology. For example, courseware designed for the normal students might not be fully accessible to DHH students and this given that there is a language barrier such as the use of text-based English vs. the visual based American Sign Language (ASL) [79]. Parton [59] found within several studies that deaf students were keen about e-learning systems that assisted their academic life. They enthusiastically attempted reading activities by using their language on information technology, which supported the notion of elearning layout. Richardson et al. [63] in their study mention that communication was easier in elearning than in a traditional classroom setting. With an increasing focus on e-learning systems, research is needed to examine whether LMS is fully reachable to deaf students and whether this technology needs further development as some recent literature shows that deaf students are enthused by e-learning [47]. In fact, the gap between desire and reality is huge in this field and there are a lot of challenges facing deaf students and developers to try to close the gap. For example, deaf students often lack access to written communication; they cannot execute professional academic activities including minimum skills with written language, and cannot access higher levels of education [11]. In addition, the poorer reading knowledge level has not improved much over the years based on Traxler [78]. According to Holt et al. [35], the standardized reading achievement scores for deaf students' in the United States remained challenging. Finally, the Web Accessibility Initiative of the World Wide Web Consortium identified the most barriers faced by deaf and hard of hearing students in Table 1.

Visually Impaired Barriers	Hearing Impaired Barriers
Inaccessibility of LMS / course	• Lack of captions or transcripts of
management systems	audio and video, including
Inaccessibility of course	web/podcasts.
Notes/materials in PDF, PowerPoint,	• Lack of content-related images in
Word and so on.	pages full of text, which can slow
Students' lack of training of how to	comprehension for people with
use e- leaning systems	weaker written language skills.
Time limits of task completion, and	• Lack of clear and simple
• online exams/assignments	language.
Technical difficulties	• Requirements for voice input on
•• Inaccessibility of audio/video	some web sites.
material	• Complete non-existence of web
• Lack of interaction between students	sites or search engines utilizing
and professors	sign language as a mark-up
	language.

Table 2.1: Barriers of Students Indicated Various Disabilities/Impairments

## 2.2 Assistive Learning Technology

Educational technology has become more and more available, flexible and involving. In a more precise way, educational technologies are developed to accomplish many roles such as

organizing the overflow of learning process through virtual networking and closer distances, along with facilitating learners' life. A great deal of literature has tried to find the best definition for educational technology but the rapid progress of this technology keeps the concepts open and unpredictable. For example, Paulus [60] simplified the definition and said that e-learning technologies should contain e-learning media and devices. For some years, many studies have presented concepts of E-learning media with reference to the real applications related to this concept. Firstly, e-learning media are online software used to post students lectures, [17]; its applications consist of discussion boards, e-mail, instant messaging, text messaging, blogs, chat sessions, e-books. As well multimedia presentations allow students to access their professor, course content, and other students [11, 34, 71, 76, and 80]. Secondly, e-learning technologies are used in web-based instruction and measured by procedure tracking [12, 36, and 82]. Thirdly, elearning tools are hardware devices that allow students to access synchronous and asynchronous online instructional actions. In addition, its application consists of personal computers, laptops, netbooks, portable media players, and Smartphones are hardware devices that can be used by students to access online instructional actions [32, 76].

Finally, distance education is a formal educational process in which students and their professor are not in the same place [69, 73, and 58]. In addition, distance education occurs when students are at a distance from their professor and operate some e-learning tools to access e-learning media and participate with their professor, the content of the course, and other students [4]. Their definitions show that several research areas are contributing to e-learning. As a result, mixed learning has grown from basically connecting old-style classroom teaching to online distance education to covering many distribution media that are designed to complement each other and the advancement of the educational process [71]. However, from year to year the technology has changed and academics have had to incorporate new technologies into their online education programs [2]. In addition, the new changes will enable learners to use radio, television, audio tapes,

and video tapes as well as teleconferencing and videoconferencing via satellite communication in distance education courses [56].

#### 2.2.1 Assistive Technology

Assistive technology has been defined in federal law in the Individuals with Disabilities Education Act of 1990 (Public Law 101-476) [27]. The term assistive technology is defined as "any item, piece of equipment, or product system; that is used to increase, maintain, or improve functional capacities of individuals with disabilities."

Over the years, the combination of a rich set of learning tools into a framework of elearning model has provided all students with powerful capabilities in navigating, studying and comparing a set of applications. However, a combination of e-learning technology and assistive technology produced e-learning systems that support the solution of special needs students' problems by different applications and different disability types. In this section, we will present some capabilities and applications of the assistive technology in e-learning management systems. With the progress of technology, the studies show advanced assistive technology, which is developed to solve special needs students' problems on the basis of their abilities.

#### 2.2.1.1 Assistive Technology Advantages

The advantages of online education for students with disabilities have been described widely [70]. Data are also accessible which indicate that participation by students with special needs is connected to a better academic routine [70]. Notably, a new educational technology technique can be used in order to help all students through life-long education by continuing to be a comprehensive method for students with disabilities. In addition, these technologies are used to enhance, sustain or develop special needs students' academic life. Assistive technology has become the more generally used term for the wide range of provisions available to assist students with

different cognitive, sensory, physical, communication, learning, and other challenges that limit sharing and learning chances. In addition, this technology allows a student with a disability to work around his/her space of experience. On the other hand, assistive technology does not provide a "medication" for a situation or disability; it helps the student to complete a task more independently. Along with that, it provides solutions for students who experience hurdles to learning or other searches as a result of disabling situations.

Assistive technology can help a student with learning disabilities to be independent in their life, and can give them also more selection and better freedom in everyday life, so it offers tools to assist student to experience success at home, at school, and at work. Assistive technology helps disabilities students of all ages, and if successfully applied, it can give student's confidence and self-respect, enhancing the quality of life. As a result, assistive technology can eliminate barriers to probable work and educational opportunities.

On the other hand, the necessary standards for technology must allow access to university systems and the internet from a collection of sites at different times of day.

E-learning systems have been proposed using, as simply as possible, those assistive technology tools which lead to making the best compromise about how to use a computer and the internet. In addition, technical provision when and where students are using computers, online libraries which help students to access indexes and electronic texts, support for professors to integrating technology into courses, and responding to the needs of students (e.g., online application, e-mail, course and university information on the web). The same standards need to be applied to students with special needs [22].

## 2.2.1.2 Assistive Technology Types

In General, assistive technologies have three types of devices classified gradually based on the easiness and how each type can meet the students' needs. The following, taken from the Abledata website [1], will explore these types and their features to classify them later on based on each type of student disability.

1. Low-Tech Devices: Here are some examples of low-tech tools that can be used to assist special needs students with different disabilities to participate in e-learning systems:

a. Small whiteboards can be supportive for deaf students who find it challenging to answer questions orally in class.

b. Communication books with pictures representing regularly used messages can assist a nonverbal student to communicate.

c. Timers can be used to show how much time an activity will take, assisting students rate themselves during academic tasks.

d. Line magnifiers, which enlarge a line of text, can be supportive to students with vision impairments.

e. Seat cushions can assist students with mobility disabilities to maintain the position needed to use their arms or hands effectively.

2. Mid-Tech Devices : Here are some examples of mid-tech devices that can assist special needs students with different disabilities to participate in e-learning systems:

a. CD players with audiobooks allow struggling readers to listen to text as they look at the words in printed books.

b. Digital audio recorders provide a way for students to practice reading aloud.

c. Amplification systems can be useful for students with hearing impairments.

d. Specialized calculators, such as those with large displays or speech output, can be helpful to students with vision impairments.

e. Hand-held talking dictionaries can be useful to students who have difficulty with reading or spelling.

f. Talking switches can help nonverbal students participate more fully in classroom and social activities.

3. High-Tech Devices : The following is a sample of high-tech devices that can assist special needs students with different disabilities to participate in e-learning systems:

a. Text-to-speech software enables a computer to speak digital text. Talking word processing software provides students with auditory feedback, enabling them to more easily correct spelling and grammar errors.

b. Word prediction software can be helpful to students with physical disabilities, as well as students with learning disabilities, because it minimizes physical effort. When the student types a letter of the alphabet, the software presents a list of word choices that begin with that letter.

c. Speech recognition software allows a student to speak into the computer through a microphone and have the text appear on the computer screen.

d. Augmentative communication tools and applications enable non-verbal students to communicate. The user selects symbols or pictures from a menu or series of menus and the device speaks the words.

The Abledata website [1] offers thousands of assistive technology devices on the market, as well as many common tools that can function as assistive technology. The above does not try to explain the focus on the most used devices in this technology. Many tools can also be supportive for special needs student. The same tools may be helpful to students who need to use them in elearning systems to confirm their own work. Providing special needs students with access to these tools within e-learning systems will allow us to involve them with other normal students. The following describe more specialized classification related to assistive technology, but this classification precisely links some of these tools that are involved with e-learning systems and based on disability types.

## 2.2.1.3 E-Learning Assistive Technology For Visually Impaired

The following are some devices and software that help visually impaired students in e-learning systems:

## Text To Speech Screen Reader :

A screen reader is software that allows students who suffer from visual impairments to use a computer [33]. Screen readers work with computers to offer information about icons, menus, dialogue boxes, files and folders [24]. There are many ways that screen readers can transfer reaction to persons who use it, and two of those ways are

- Speech ( Text To Speech )
- Braille

Using a screen reader to translate information of texts on-screen to speech, which can be heard via earphones or speakers, is called Text-To -Speech. "A Text-To-Speech is the most powerful software application that comes with the screen reader, or it may be a hardware device that connects to the computer".<sup>1</sup> Screen readers are also able to provide information in Braille and need an outer hardware device. Updatable Braille contains one or more records. Every cell can consist of the shape of a Braille character, a sequence of dots similar to a domino design [24].

## DAISY Technology

The DAISY design was developed for students who have obstacles that make it hard or

<sup>&</sup>lt;sup>1</sup> (http://www.nomensa.com/blog/2005/what-is-a-screen-reader

impossible for them to read normal print. So generally this includes students who are blind or visually impaired, students with cognitive dysfunctions such as dyslexia, and students with limited movement skills who might not be able in carrying a book or turn pages. Digitized data can be rapidly sent through the web and can be reached on many types of assistive devices. For example, a "DAISY audiobook can be played on a computer or mobile device using software or a screen reader or on a player such as the Victor Reader Stream".<sup>2</sup>

The text can also be enlarged for those with low vision, or converted into braille for printing or reading on an updatable Braille display [17].

## ✤ JAWS Screen-Reading Software (Standard)

- A JAW is a strong solution that reads information on the computer monitor using combined speech. A JAW provides a lot of commands that facilitates to use programs, edit documents, and read Web pages.<sup>3</sup>
- In addition, JAWS is a screen reader for visually impaired PC users who cannot see screen content. JAWS read loudly what is on the computer monitor, and allows the user to use quick tools to access Web pages and all screen content [52].

## **\*** Dragon Naturally Speaking Premium Edition

Dragon allows disabled students to relate with their computers by voice. In addition, Dragon NaturallySpeaking 12 Premium is new stage of efficiency by giving freedom and flexibility to command or change documents, spreadsheets and presentations, send email, search the Web, etc. [52]. Also, while taking notes on the move using a digital recorder, Dragon will copy the audio files back to disabled students' computers.

<sup>&</sup>lt;sup>2</sup> (<u>http://www.daisy.org/daisy-technology</u>), (<u>http://assistivetechnology.about.com/od/AudiobookPlayerOptions</u>). <sup>3</sup> (<u>http://www.quantumrlv.com.au/blindness/blindness-software-solutions</u>).

## **\*** MAGic Screen Magnification with Speech Software

The MAGic can help the students with low vision to use Web and other software applications, such as creating and reading documents, e-mailing, engaging in social networking, or browsing the Web. The advantage of MAGic is built-in human-sounding voices by reading documents, e-mail, and Web pages while users follow along, and remove color glow to make computers become more legible, and reduce eye strain for low vision students.

## **\*** Braille note takers & displays

A notetaker is a good solution for the blind and visually impaired. They can use it to surf the internet, take notes, sync their calendar and contacts, and read silently through the use of a refreshable Braille display [33]. There are many types such as:

- Perkins style keyboard for entering information and synthesized voice for outputting information
- Voice Sense Qwerty: the features of it are a built-in GPS receiver and compass, WiFi and Bluetooth
- Braille Sense OnHand



Figure 2.1: Braille note takers

## ZoomText Mac

A screen magnification program can expand and strengthen everything on the computer screen. It can also adjust Screen Colors. It is for low vision students or students who need small batches of magnification.

## 2.2.1.4 E-Learning Assistive Technology for Hearing Impaired

The following devices and software are used by the hearing impaired in e-learning systems.

## **\*** Amplification Devices

Assistive Listening Device (ALD) which is a technology that actually improves hearing for students with Hearing Impairments allowing them to hear sounds installed on the body, behind the ear, or on the eyeglass that help to amplify sound.<sup>3</sup>

Telecommunication Device for the Deaf allows hearing impairments students to receive phone calls using technology hanging on phone that has a small keyboard and screen for typing.
 But this device is not used regularly in the lectures.<sup>4</sup>

a. Ubiduo communication system

It is a device which helps the deaf and hearing impaired students to communicate

face-to-face with other students.<sup>5</sup> **Captioning:** 

Captioning allows spoken word on computer or website to be translated into typed English for hearing impaired to read. This type of assistive technology is most prevalent e-learning environment.

<sup>&</sup>lt;u><sup>3</sup> http://sped.wikidot.com/assistive-technology-for-students-with-hearing-impairments</u> <u><sup>4</sup> http://sped.wikidot.com/assistive-technology-for-students-with-hearing-impairments</u> <u><sup>5</sup> http://www.fresnostate.edu/studentaffairs/ssd/services/ubiduo.html</u>

a. Caption Mic<sup>TM</sup>:

 $Mic^{TM}$  is a tool restores what was said by professor into a microphone that converts the speech to text that can read by the deaf or hard of hearing individual.

### ✤ Voice to Text / Sign

Voice to text is service software to convert voice to printed text or translate what people have said, and voice offers recognition for information in sign language. The user needs to work with one device to train this device to identify their voice [49].

## 2.2.1.5 Assistive Technology That Is Available in Canadian Universities

### 1- Kurzweil 1000 or Kurzweil 3000:

It is an assistive software technology for students who are visually impaired. It reads print and digital documents, zooming text documents, and online information search and retrieval.

It blends the normal ability of reading machines with methods of communicating efficiently to help improve work and reading. Such as scanning, image processing, and text-tospeech with communication and productivity tools help users' read and write.

At Laurentian University website [47] Kurzweil 3000 "is an assistive technology which provides reading, writing and study platform aimed at people with learning disabilities or other disabilities that make reading or writing difficult. Kurzweil 3000 is used to support those with Dyslexia, Dysgraphia, and English Language Learners in school, higher education, at home and in the workplace. Kurzweil 3000 can read aloud web-based, digital or scanned print material, convert web-based, digital or scanned print materials into mp3 to provide audible files to listen to on the go or through its firefly web app can be read on an IPod".

## 2- Texthelp's Read &Write Gold:

"Texthelp Systems create literacy software to help students with print disabilities, i.e. User is unable to read standard printed material such as dyslexia and visual impairments, improve reading, writing, and research skills".<sup>6</sup> **3- Inspiration** 

"Inspiration is a software tool for visually representing ideas. Students can create graphic organizers and story maps for charting content, either as a precursor to writing or as a study support. The software provides the ability to move between graphic representations and text outlines".<sup>8</sup>

The above tools are examples, but there are many others because the growing use of technology has been accompanied by a significant growth in the number of applications, software, and devices. Many of these technologies are useful for both students with disabilities or without. Some of these technologies can be integrated with the existing e-learning management systems to facilitate students' life. To see if the assistive applications have the ability to integrate with the learning management systems, we need to know what the capabilities of existing e-learning systems are in order to build a comprehensive vision from different perspectives. The comprehensive vision will act as a roadmap to evaluate, analyze and build our new prototype. Providing all students with a prototype to access these applications helps realize the goal of involving these students in the same e-learning system used by others.

<sup>&</sup>lt;sup>6</sup>: <u>http://www.unh.edu/disabilityservices/assistive-technology</u>.

<sup>&</sup>lt;sup>8</sup>:<u>http://www.unh.edu/disabilityservices/assistive-technology</u>.

Visually Impaired assistive	Hearing Impaired assistive
technology	technology
Text To Speech Screen	Amplification Devices
Reader.	Telecommunication Device
• DAISY Technology.	• Ubiduo communication system
JAWS Screen-Reading	Captioning
Software (Standard).	➤ Caption Mic <sup>TM</sup>
Dragon Naturally Speaking	• Voice to Text / Sign.
Premium Edition.	
MAGic Screen	
Magnification with Speech	
Software.	
• Braille note takers &	
displays.	
ZoomText Mac.	

# Table 2.2 E- Learning Assistive Technology for Disabilities/Impairments

# Chapter 3

# Prototype Design For E-learning User Interface

Chapter three explains the steps that have been followed for designing an e-learning user interface for visual and hearing impaired students. The collected data was from visual- and- hearing impaired students by conducting an interview with some of the participants in this study. This data was the best way to meet the collective requirement based on their preferences to integrate the tools into the e-learning system without using any assistive software. As a result, they chose one of two alternative prototypes offered to them. This chapter also presents the research methods that have been applied in the thesis.

#### **3.1 Theoretical Perspective**

The goal of this research is to find a better design for an e-learning user interface to integrate the visual-and-hearing impaired students to help them use and understand the tasks in an e-learning user interface. D2L at Laurentian University was used as an example for students to use the user interface without any assistive software technology. The scope of the design of the e-learning user interface is discussed as well as the way the data was collected to give some ideas to design the e-learning user interface, analyze the requirements, and then design a prototype of the elearning user interface. In addition a comparison of the D2L user interface as an e-learning system with the user interface designed and developed in this research work. Two main topics are discussed in this chapter. The first is related to data gathering of the most important requirements for desirable e-learning interface based on special needs students' perspectives. The second is related to designing the prototypes based on the requirements that were gathered from the interviews of the special needs students.

### 3.2 Research Methodology

The methods that have been applied to evaluate the usability testing of e-learning interface are: quantitative, qualitative and experimental. In the qualitative part, the data collection included semistructured interviews and open-ended questions to visual- and- hearing impaired students at Laurentian university. After designing an e-learning user interface based on their requirements, a quantitative method was followed by asking them to fill out two surveys that ask the same questions to compare between the existing D2L e-learning system at Laurentian University and the proposed design that was developed. The survey questions asked the participants to rate many factors such as accessibility, ease of use, usefulness and so on. Their relative satisfaction with the usability of the e-learning user interface was also rated by using an experimental method which allows participants to experiment with multiple tasks such as button voice, Tab voice, and voice reading for web page, sign language for commands and uploading video and audio with sign language on the user interface. These commands were tested and compared with the commands on D2L interface by the participants. As well, this survey includes questions regarding the usability factors related with the integration of the tools in the D2L e-learning system. The survey had ten questions that have been ranked on a 5-point Likert scale as shown in figure 3.1, ranging from 'Strongly Disagree' to 'Strongly Agree'. The collected data was analyzed.

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	
1	2	3	4	5	

Figure 3.1: Five-	point Likert scale
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### **3.2 Research Questions**

The questionnaire consisted of the following questions asked to the students with visual-andhearing impairment to understand their requirements and preferences for the user interface.

1. Is the user Interface for visual and hearing impaired students able to deliver the promised services dependably and accurately?

2. Does the user Interface for visually and hearing impaired students provide fast and reliable exploration capability?

3. Are the visually-and-hearing impaired students satisfied with using the user Interface of the elearning system?

4. Does the user Interface of the e-learning system have good appearance and navigational design?

5. Does the user interface of the e-learning system meet visually- and- hearing impaired students' needs?

# **3. 4** Data Gathering for requirements of E-learning User Interface for visually and hearing impaired students

The techniques that have been used for gathering data for prototype requirements are the following.

- Face-to-face interviews with groups of visually- and- hearing impaired students to know what exactly the elements are that they need in the new e-learning user interface.
- Two alternative designs that match with their needs were shown; students chose the

one most helpful based on their requirements.

- Design, implement and develop the new e-learning user interface

- Test the tasks of the new e-learning user interface and compare it with the existing system.

- Let the students evaluate the design after testing each task in the new e-learning user interface.

- Fill out two questionnaires from participants for the existing and the new e-learning user interface.

The schedule to organize the data collection, design and evaluation of the e-learning user interface

is given in Table 3.1.

Table 3.1: Schedule for organizing the collection of data, design, evaluate for e-learning user interface.

Steps	Start Date	End Date	Notes
Interviews of participants	5/03/2014	12/03/2014	
Participants choose the prototype	13/03/2014	17/03/2014	
Participants give their opinion of prototype.	17/03/2014	21/03/2014	
Design the e-learning user interface.	24/03/2014	30/03/2014	
Evaluate the interface by survey	1/04/2014	8/04/2014	
Get result	8/04/2014	15/04/2014	
Analyzed results	15/4/2014	20/04/2014	

### **3.4.1 Interviews**

Interviews were conducted with 5 students who are hearing- and visually- impaired students at Laurentian University, which represent half of the population (10 students). The interviews were conducted with each of them to explore the various issues about their needs in using the D2L

elearning system at Laurentian University (**user interface**). Before starting to design the user interface, face-to-face interview method was used to collect some ideas and to understand students' needs concerning e-learning user interface (D2L user interface) at Laurentian University. This would make the new e-learning system more helpful. Visually-and-hearing impaired students were asked about the tasks that they prefer to view in the new e-learning system without using any of the assistive technology that they use on their computers.

Based on their information, the tools to be integrated in the D2L e-learning system include:

Commands in D2L; they prefer to have a voice to listen to what the command is (Voice Commands).

They prefer if the D2L has a zoom text option that is easy for the visually impaired to maximize or minimize the text that makes reading of the text more clear.

▶ If they can read or have them explained any chart in the content of the course.

Some of them prefer special colour for the font or background.

➢ No brightness.

Some of the visually- impaired students have colour blindness (they prefer the background of menus be black and the text to be white).

Hearing- impaired students prefer to see the lecture as a video with sign language or loud audio.

> If they can understand the graphs and charts, for example using sign language.

> There is no problem with colour for hearing- impaired students.

### **3.5 Prototype Designs**

In designing an e-learning user interface, we need to collect information about the capabilities of the e-learning system and the needs of the students. Microsoft developers [54] suggested good

principles for designing the layout of the user interface. The following are some principles that should be followed.

• Colour: designers should consider the UI colour carefully, because colours get a user's attention and many individuals perceive colours differently and so designers should not rely on colours to communicate information. In addition colour contrast is also important because designers should ensure there is enough contrast between foreground and background colours.

• Typography: is another important feature to consider in designing the UI. The Microsoft developers recommended "Font size, font weight, and the spacing between letters, words, and paragraphs are also important. We should avoid sizes that are too large or too small. It is often helpful to make the font size of a text field slightly larger than the surrounding text, but we need to take into consideration the size of the page and avoid forcing the user to scroll down if possible".

• Balance and Symmetry: this is related to the distribution of visual weight and whether it is symmetrical or asymmetrical. Symmetry is appropriate for a traditional audience because it can communicate stability and/or strength. Asymmetry is appropriate for a modern audience or an entertainment website because it has a more informal balance.

• Consistency means the page layout, colour, and typography throughout the UI should be consistent with each other. Designers should be mindful of UI control choices to ensure consistency across all applications.

• Simplicity is the simple and logical layout of the UI that lets users executes important features and/or tasks. This is achieved by limiting the number of animations, special effects, colors, gradients, fonts, and other design options.

The user interface design should show a suitable level of consistency and the commands and menus should have the same format based on their level of impairment. For example, for visually- and

hearing -impaired students we should care about the typography such as typeface, interlinear space, word spacing, and colour. So any typeface on user interface design can be used if we use it large enough.

The standard of the Royal National Institute for the Blind (RNIB) "Recommends a minimum font size of 14 point for readers who are likely to be blind or partially sighted." For headings, use a font size at least two points bigger than the body text. Leave reasonable space between lines of type. RNIB suggests interlinear space should be at least +2pt for type sizes between 14pt and 20pt. Always use even word spacing: In some documents for the visually impaired, it has been the tradition to use double word spacing. This has not been fully researched. While it may help some readers, others may find double word spacing actually hinders reading. There are also multiple types of colour blindness; more common cases are an inability to recognize blue/yellow or red/green. "<sup>7</sup>

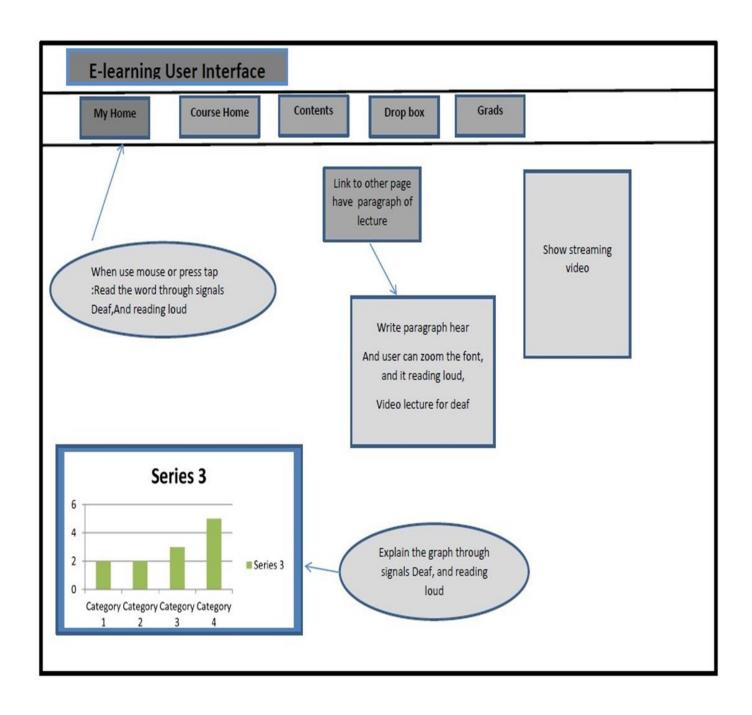
However, the new e-learning user interface follows these standards by considering the fluctuation in student ability; for example one student preferred the white background and black text but others did not. The new user interface gives them the choice to select the colour based on their needs.

### **3.5.1** Choose alternatives

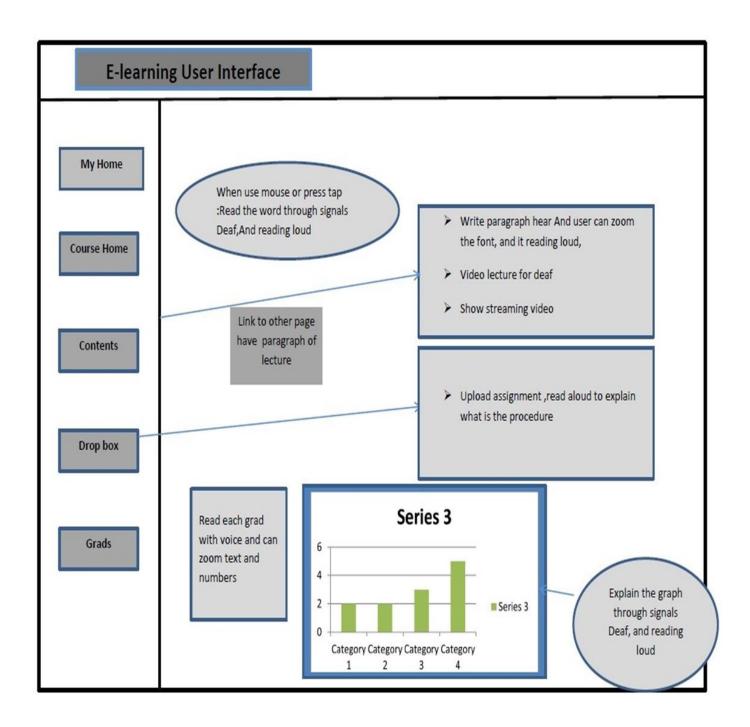
After interviewing visually- and hearing-impaired students two alternative e-learning user interfaces were designed (see Figure 3.2, 3.3). Before starting to implement the design, another interview was conducted with the participants to make sure that the suggested design covered all the tasks that they preferred to see in the e-learning user interface. They were asked to choose the best alternative that would give them ease of use, ease of movement, and ease of choice functions. However, both alternatives have the following commands and each command has some tasks: My

<sup>&</sup>lt;sup>7</sup> http://www.reading.ac.uk/web/FILES/simplification/lucidmarkbarratt.pdf

Home, Course Home, Contents, Drop box, and Grades. For example visually- and hearingimpaired students can use a mouse or tap the bottom of the keyboard to choose one of the above commands. The system reads the command and gives them the sign language for each one to help hearing and deaf students understand the command; for the visually- impaired it will also read aloud each command. Nevertheless, the participants chose the alternative design shown in Figure 3.2 as this design was closer to the e-learning user interface they used in D2L in terms of the order of the tasks and the format.



**Figure 3.2: Alternative Designs** 



**Figure 3.3: Alternative Designs** 

# **3.6 Data and Population 3.6.1 Participants**

The number of visually- and hearing- impaired students in Laurentian University is limited. The whole population at Laurentian university was targeted to evaluate the suggested e-learning interface, which consists of ten visually and hearing impaired students, 5 students out of ten students who responded and tested the design which consisted of 50% of the population that tested the design and answered the questionnaire. All visually- and hearing-impaired students were selected from different programs at Laurentian University. However, the participants tested the routine tasks by using D2L user interface and also the proposed e-learning user interface and then filled out the survey questionnaires about their experience while using both the systems. The routine tasks, a voice and sign language are clear, the upload and download file is good; they can read their grades by voice or zooming text, and read a chart by sign language or voice, and so on.

### 3.6.2 Facilities and Equipment's

The classroom in the accessibility office at Laurentian University was chosen to carry out the test. The two interfaces (proposed e-learning user interface, D2L user interface) were provided to the participants to make their evaluation. The equipment included the laptop computer and a mobile phone in order to record the time. Before the participants started to fill out the survey they tested both user interfaces after a short introduction in which the experimenter explained the study to the participants; then participants started to test the user interface and filled out both questionnaires. The questionnaire can be seen in Appendix B. All participants finished testing both user interfaces and fill out two questionnaires within 30 minutes.

### **3.7 Ethical Considerations**

All participants were asked to participate in the study voluntarily. After obtaining the ethics approval certificate from the Ethics Board, the experiment was started. Consent form was given to each participant to let them know the purpose of the experiment (see Appendix A).

# Chapter 4

# Implementation of the E-learning User Interface

This chapter describes in detail the design and implementation of the proposed e-learning user interface prototype that has been implemented and developed based on Laurentian University special needs students' requirements. An experimental method is described that was selected to compare the design of a new e-learning user interface prototype with the D2L user interface prototype.

### 4.1 User Interface for People with Visual and hearing Impairments

We can't overlook that there are many studies that are interesting and that discuss the principles of design of user interface for people who have vision and hearing impairment [16]. As well, Darejeh and Singh [16] recommended designing UI for visually–and-hearing impaired users based on their preferences and by giving them some options for choosing and controlling some commands such as font and colour [50]. Furthermore, some scholars expand that by giving them also a number of keys such as controlling the zoom in the user interface , enhancing and putting speech recognition to make the user interface more interactive, rather than customize the font size and colour [74, 13]. In [78] the study focuses on interface for people with different levels of visual and hearing impairment, suggested making UI accessible, and that the designers should use a "combination of features such as speech input and output, gestures, haptic feedback and a zoom-able graphical interface". That means that the e-learning designers and developers should always have the user's preferences when designing an e-learning user interface. Because of this, the literature focused on design principles in term of user preferences "like suitability for task, self-descriptiveness,

controllability, conformity with user expectations, error tolerance, suitability for individualization, and suitability for learning". The literature also confirms that user preferences may have differing relative importance in given specific situations [67]. Taking user preferences in designing an e-learning system for students with disabilities by getting those commands could lead to the elimination of unnecessary stress and frustration that can make impact on UI usability for e-learning system [26].

### 4.2 D2L E-learning System

Listening to the perceptions of visually- and hearing- impaired students about the D2L (see figure 4.1) e-learning system at the Laurentian University [47] provided the understanding of the barriers faced by them while using D2L without any help from assistive technology. The following is an example of the opinion of a visually- impaired student who was interviewed (see Section 3.4.1). She said that the most important obstacle that she had encountered when using D2L at Laurentian university was the lack of commands that help visually impaired students, such as zooming the texts. She could not use any computer at Laurentian University to access the e-learning system (D2L), but she brought her Laptop because it contains an assistive software named (a magnification program) zoom text. She noted that if anything happened to her laptop (broken or lost) she could not view nor do her assignments. In addition, this student is not the only one facing this barrier; others who had glasses faced difficulties reading their grades for assignments or could not view course content and so on.

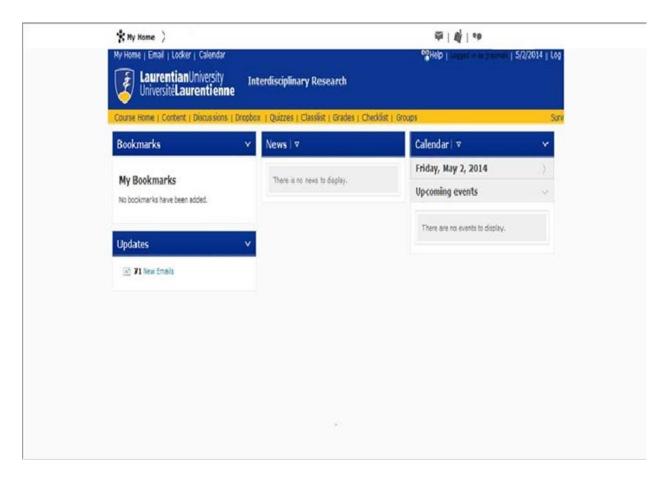


Figure 4.1: D2L e-learning user interface at Laurentian University.

### **4.3 Implementing the proposed design of the user interface**

Figure 4.2 shows the user interface design for the e-learning system that was selected by visuallyand hearing- impaired students through the interviews and questionnaires. Internet websites application languages were used to implement the e-learning user interface.

E-lea	E-learning			LaurentianUniversity UniversiteLaurentienne	
My Home	e C	ontents	Dropbox	Grades	
Other Links		Intro	duction to Pr	oject Management	
Bookmarks     Upcoming I     Table of Co     Fant Size	ivents intents	program	Project Management is a three-credit elective course in the degree program for the Master of Business Administration, offered by Laurentian University.		
Smitt Default Font Color White Black	Large	Cours	e description	and purpose	
Yellow Orange Background Co	Blue Pink			aned to convey the methodology re ects of various natures and magnitu	
White Black Yellow Orange 4 secs		manager	rs who are intereste	become project managers and pro d in sharpening their skills will get ar individuals who may be involved	the most

Figure 4.2: E-learning user interface that was implementing

### 4.2.1 Tasks inserted on the e-learning user interface design

The e-learning user interface has multiple tasks in an effort to help visually- and hearing- impaired students when they use the e-learning user interface. Multiple tasks include button voice, Tab voice, voice reading for web page, sign language for commands and uploading video and audio with sign language on the user interface, zoom texts, and control of colour of font and background. These multiple tasks that are implemented in the design of the proposed user interface are explained below.

### ➤ Task1:

The tool bar was built to enable student to choose one of the available commands by a mouse click for hearing- impaired students and by moving within a tap through the keyboard for visually impaired. They can also view sign language that explains what this word is and listen to loud sounds to read the same word (see figure 4.3).



Figure 4.3: Use of sign language to read words in tool bar.

### ➤ Task 2 :

From the left side of the following screen, the student can control his/her font size preferences by zoom text (small, large, and default); this feature is on all pages in the user interface with voice read (see figure 4.4; figure 4.5).

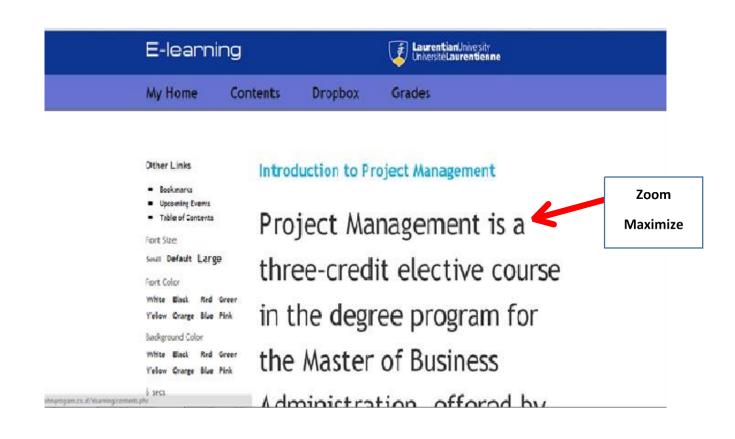


Figure 4.4: Control of zoom text to large.

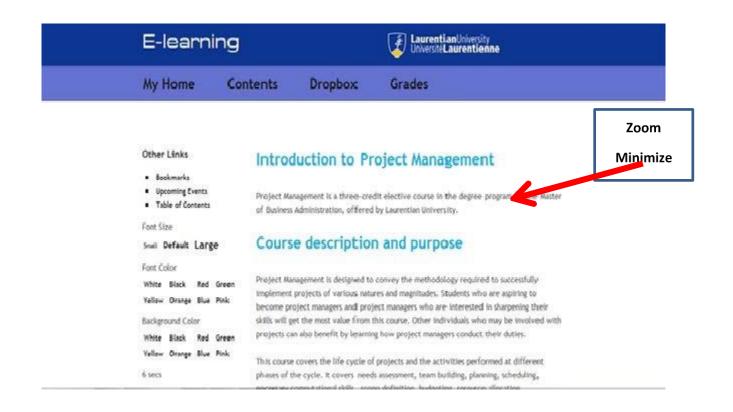


Figure 4.5: Control of zoom text to small.

### ≻ Task 3 :

Students can also control their font colour or background colour based on their preferences. This option was developed for students who have color blindness or other students who prefer a special colour (see figure 4.6).

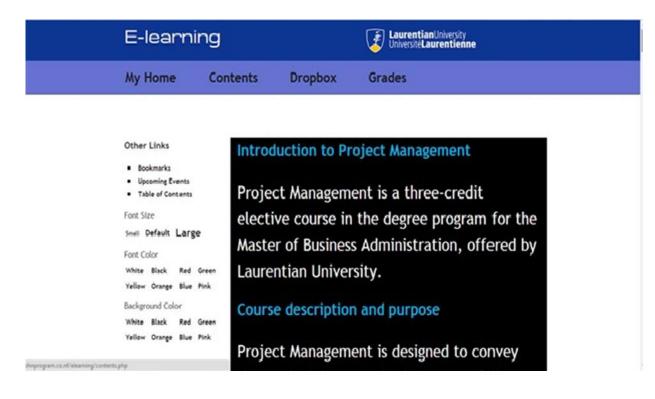


Figure 4.6 Control of font and background colour.

### Task 4:

This task gives students the opportunity to understand a graph by reading it by voice and by having

it explained by sign language (see figure 4.7).

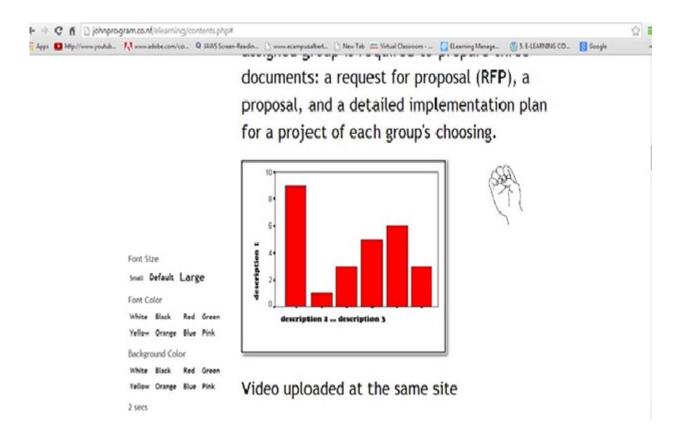


Figure 4.7: explain graph by sign language and voice.

# **>** Task 5 :Streaming media

Visually- and hearing- impaired students can also view a complete video and audio with added sign language. (See figure 4.8).

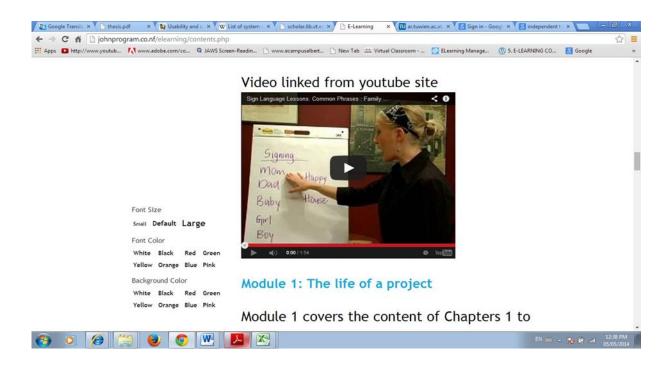


Figure 4.8: Streaming media for lecture with translation of sign language.

# Chapter 5

# A Framework For E-learning Architecture

In this chapter a new architecture is proposed by adding a streaming technology to the existing architecture of D2L e-learning system at Laurentian University. Briefly, related subjects have been defined to give the readers an overview of merging streaming technology with e-learning systems.

### 5.1 Streaming technology

By exploring various special needs students' impairments, we are able to show that streaming technology within academic e-learning environments has become very essential. Streaming technology has increased the capability of special needs students to exchange information through online lectures in various ways. For example, "recording a video of the entire lecture containing the picture of the board, the lecturer, and an audio track enables students to follow a lecture remotely or to replay previous sessions" [25]. The progress in these technologies allow online lectures to be received at any time and place, as many times as necessary, by streaming sound, video, images, and text via the Internet [3]. The online lectures are also compiled in PowerPoint, combined with video and audio, and placed on the e-learning system so that the special needs students can attend lectures at any time and place, as many times as they want [3]. The online lectures are helping all students in general but deaf and blind students in particular, especially when a streaming technology is included.

#### 5.1.1 What is Streaming media?

Streaming is a technique that allows users to hear and view digitized content-sound and video as it is being downloaded over the Internet [9]. As well, streaming technology as a method is a reliable technique of streaming video content over networks to a number of classes of devices including smart phones, tablets, laptops and desktop personal computers (PCs) connected to small and medium-sized screens [64]. Streaming media applications (see Figure 5.1) are a good way to integrate video and audio combined with sign language into an existing e-learning system. This integration allows students and special needs students, particularly deaf and blind students to grasp the benefits from this technology.



Figure 5.1: Streaming Media Applications [15]

E-learning as one application of streaming media can be further enhanced by using this technology for special needs students. Students can see and hear the online lecture many times, but when a streamed lecture finishes playing, it is not stored on their computer. According to Rohmann [65] streaming technology can benefit university libraries in a number of ways, such as "for storage and delivery of classroom lectures, to webcast campus events, and to provide access to audio materials in archives and special collections." As shown in Figure 5.2 the students can see the lecture live and on demand and they may be located in the university or in other places.

Remote attendance also helps reduce costs by sparing them having to move or travel [40]. Additionally, according to Kahmann, [40], "learners who want to advance more quickly may skip portions of the coursework on their own and later resynchronize with a common group timeline".

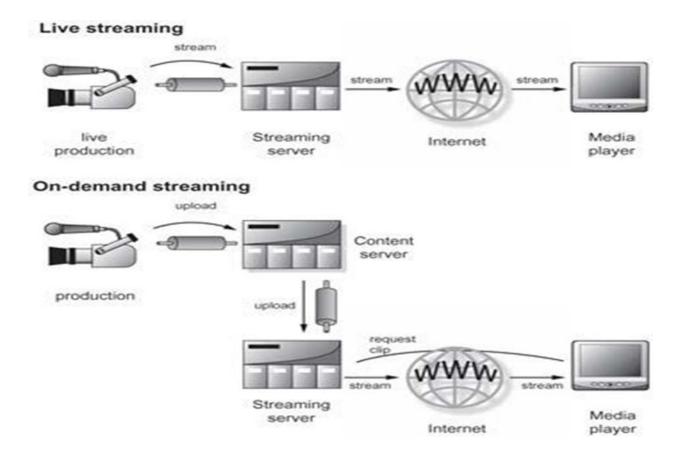


Figure 5.2: Live streaming and on-demand [15]

### **5.1.2 Streaming Technical Aspects**

To successfully organize a live streaming solution on a university web site, we suggest two parts: Platform and Content arranged in the e-Learning system. Most platforms are using a Learning Management System (LMS), emphasizing on the management of teaching and technology development. An LMS can offer teachers and students an environment for online studying with digital contents [81]. According to Weng and Lee [81], the first part will be to convert lecture content to multimedia learning content, compressed files which conform to SCORM (Sharable Content Object Reference Model) standard. The second part would be to publish on a SCORM-based learning website by uploading the compressed SCORM files into the LMS. To implement the two parts we need to publish the online lecture; however, all hardware and software shown in Figure 5.3 are primarily PC-based, as opposed to server-based and other devices if needed, such as video cameras, lights and so on.



Figure 5.3 Streaming hardware [15].

According to Figure 5.4 [72], LMS is an integrated development environment based on a server and its components to manage and transport lecture content to special needs students. Generally, the LMS has been rapidly adopted by academic universities around the world, by adding more credit in academic institutions. While LMS capabilities vary, most capabilities include support for blended learning, content integration, assessment capabilities, and adherence to standards and so on [29]. According to adherence to standards, LMS has the ability to support standards, such as SCORM. That means "LMS can import and manage content and courseware that complies with standards regardless of the authoring system that produced it"[29].

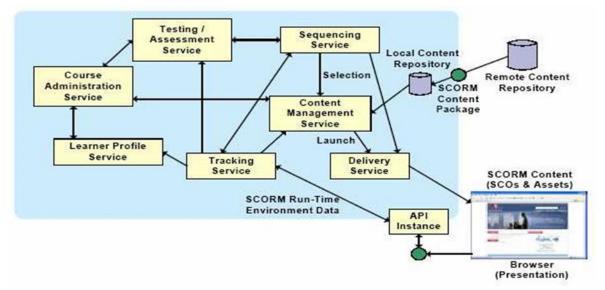


Figure 5.4 Ordinary LMS model [72]

### 5.1.3 SCORM E-Learning Course For Special Needs Students

The center of a learning content management system (LCMS) is learning content. It provides teachers, special needs students, and lecture subjects the means to create e-learning content more efficiently. Nevertheless, an LMS and an LCMS is complementary (see Figure 5.5). The international Data Corporation (IDC) defines a LCMS as a system that creates stores, assembles and delivers personalized e-learning content in the form of learning objects. Streaming software utilizes the platforms of LMS or LCMS to create a highly effective lecture with interactive media (such as video and audio) to allow staff and learners to synchronize all types of content.

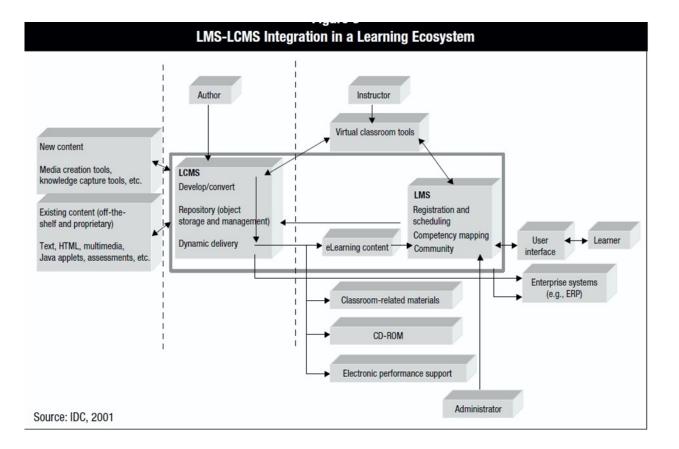


Figure 5.5: LMS-LCMS integration in learning Ecosystem [37].

As a result, this synchronization supports those lectures by publishing SCORM comprised file;

SCORM enables lecture content to be delivered and tracked with LMS or LCMS. According to

Weng and Lee [81], the following characteristics of SCORM will help all learners in the LMS or

LCMS:

- Accessibility: universal access by all learners
- Adaptability: individualized content fit to specific need.
- Affordability: cost efficiency of development.
- Durability: programs or materials remain unaffected by technological changes.

• Interoperability: materials remain compatible with any system or instructional platforms.

• Reusability: multifunctional in many contents.

After exploring these characteristics and linking them to the main purpose of this study is to know and test streaming ability for special needs students. Accordingly, streaming software *Stream Author* was used with the new e-learning user interface to experiment and use lecture content with sign language published by SCORM. *Stream Author* is a system for producing helpful interactive presentations by synchronizing video and audio with PowerPoint or other document files. Combining this presentation with sign language on the new user interface can enable special needs students – such as deaf, and blind- and their teachers to create integrated learning environment in the existing e-learning systems within universities. A new e-learning architecture is explored that can upload streaming media files as interactive software that can help special needs students.

### 5.2 E- Learning System architecture

Figure 4.14shows a framework to manage an e- learning system within an integrated academic environment that supports visual -and hearing-impaired students. The framework design is one of the main features that enable developers to understand the components of e-learning system, because it is an essential connection to map the relationship between the learners and their instructors. As a result, within this framework the users need an e-learning system that should be easy-to-use, easy-to-learn, and subjectively satisfactory.

The architectural design (Figure 5.6) of an e-learning system also gives us an initial perception of the main components in the e-learning system. The architecture design of an e-learning system has four main components: courseware, communication tools, task-based activity, and course assessment. The interface in an e-learning system allows the learners to trace courseware that contains course contents, and course information, and do an assortment of other course-related

functions. The interface also comes with a student database to manage student grades and advanced presentations. Figure 5.6 shows an overall overview of an e-learning system.

Traditionally, an e-learning system is created based on the needs of users where students or teachers can create or update their courses under the supervision of designers. In that case, teachers can control the entry of students to specific pages using access control provided by designers. As well, students who are registered in a course are granted access to the e-learning system through the interface; they can also read instructions, course materials and grades. Additionally, in this architecture the students can make submissions/ resubmissions of their homework and communicate with their teachers and with other students. This architecture shows all the transactions that happen between users, while establishing the connection to the database of the university that directly stores all data. Traditionally, the university database has many files and when the users need to explore any information in an e-learning system, they use existing mapping techniques that are already there. Then the user has the ability to call the information directly from the files that are stored in the database; for example, a grades file that contains all grades for student courses after teacher evaluation, a file of course contents, a file of assignments, a file of exams, and files containing all users' information, etc.

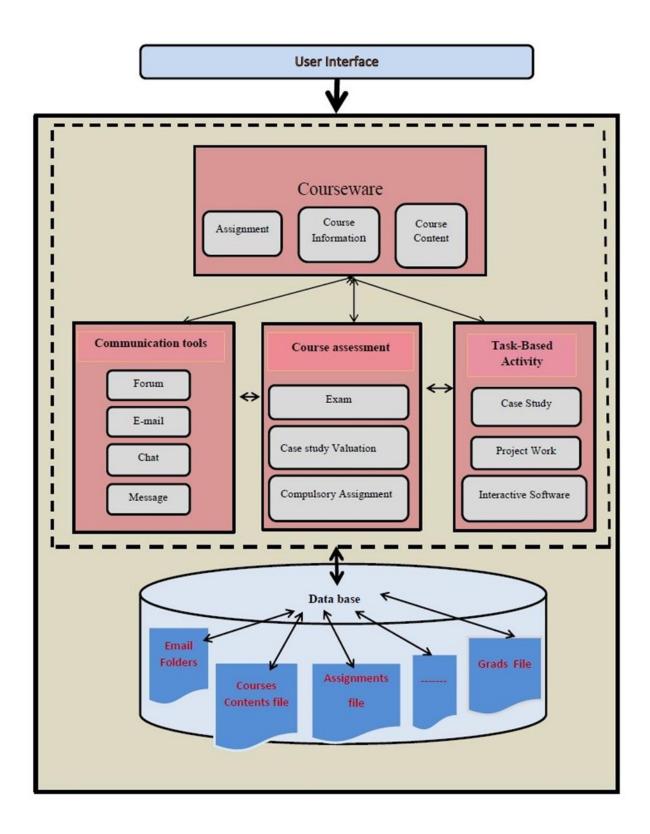


Figure 5.6: E- Learning System architecture

### 5.2.1 Courseware:

Figure 5.7 shows the courseware component which is one of the most important components in an e-learning system. According to Auringer [7] the "Interactive courseware is computercontrolled courseware that responds to individual student input in determining the pace, sequence, and content of instructional presentations". As a result, many tools and attributes enable users to create, manage and check courses. Based on the available systems, these attributes are divided into three parts: assignments, course information, and course content attributes. The assignment area consists of one or many mandatory assignments or nonmandatory assignments. The users who want to explore the past assignments in courseware in an e-learning system can submit their assignments or they can see the feedback about them. The second one is course information; in this part the users can review the course schedule, course requirements, and the past version of courses especially when they explore the course information attribute. The last one is the course content, which consists of one or more course topics and study materials (e-book, e-reading, and bibliography, etc.). This also enables students to browse their topic or subtopic for each course. On the other hand, the teachers can update their topics, by uploading and updating their lecture material. As a result, the students will see all those uploaded and updated contents by reviewing data and information in the special files of courses that have been stored in the database.

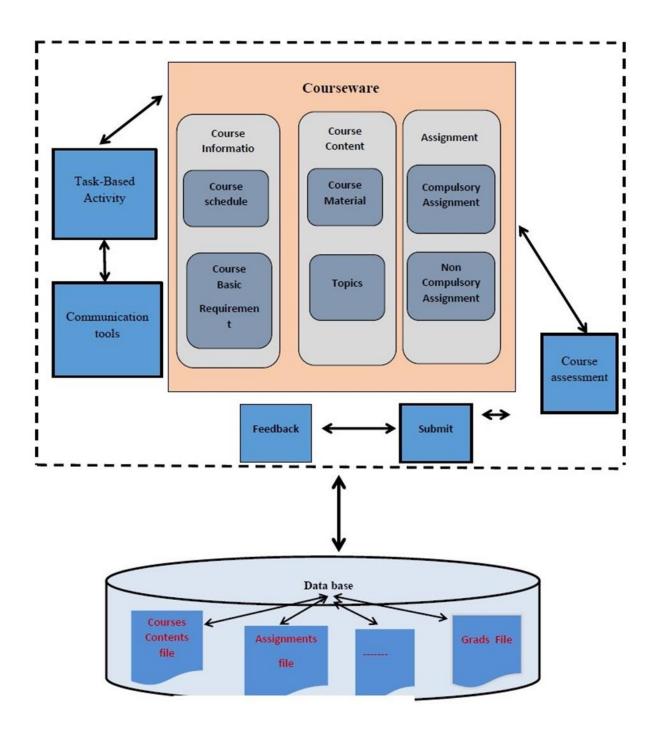


Figure 5.7: Courseware content

### 5.2.2. Task-Based Activity

Figure 5.8 shows the task-based activity attributes in an e-learning system. The important one in this figure is the interactive software part which includes a virtual reality/animation space for live communication between all the participants (students and teachers) in the learning process. Participants feel that there is a realistic interaction between them based on a synchronized connection. The interactive software also has media features that enable users to create a decent link, one or more multimedia to watch videos and record lectures and so on. Another feature searching enables teachers or students to download their information or other media. In addition, interactive software has a suitable link to the online databases. The second part of the task-based activity is the project work, this works for teachers' and students' participation and submission, and generates their feedback. The last part of the task-based activity is a case study which enables students to make their analysis and submit the result into the e-learning system to store in the database. Finally, the resources of task-based activity consist of study material for task-based learning, project reports that may be used again with modifications, research-based project tasks, and links to a wide range of educational software and modified educational resources.

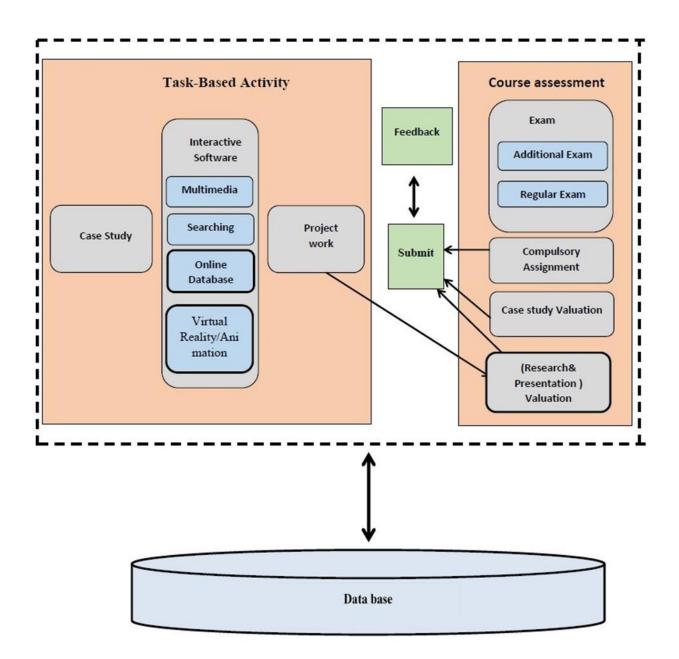
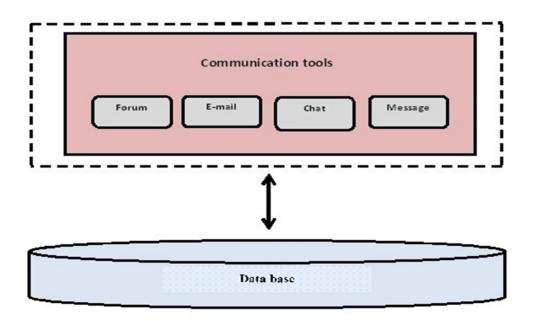


Figure 5.8: Task-Based Activity content

### **5.2.3** Communication tools

The e-learning system architecture was designed to support the communication tools of the learning cycle in figure 5.9, enabling students to test their project work by conversations, collaboration, and interacting with the teacher and their fellow students, to chat synchronous and asynchronous [30].

These tools are conducted through the online discussion and online workspace. Online discussion may be synchronous or asynchronous based on the communication session. Generally, synchronous is associated to many chat rooms and asynchronous is consisting of a lot of forum, email, and messages. On the other hand, online workspace could be none or many whiteboard and none or many Shared rooms. However, the participation process in the communication tools is connected to all facilities of online discussion and online workspace.



# **Figure 5.9: Communication tools**

### 5.2.4 Course assessment

In Figure 5.10, the course assessment offers many features for working tests, project deliverables, and self-assessment exercises, and assessment of student participation. In addition, it refers to the procedures that enable teachers to assess their students' performance in compulsory assignment, specially, the submissions that require feedback by the course teacher. The other features are related to exams, project assessment and case study evaluation, in this part the teachers upload the regular assignment online and their students can answer it. Finally, the files of course assessment are stored automatically in the e-learning database.

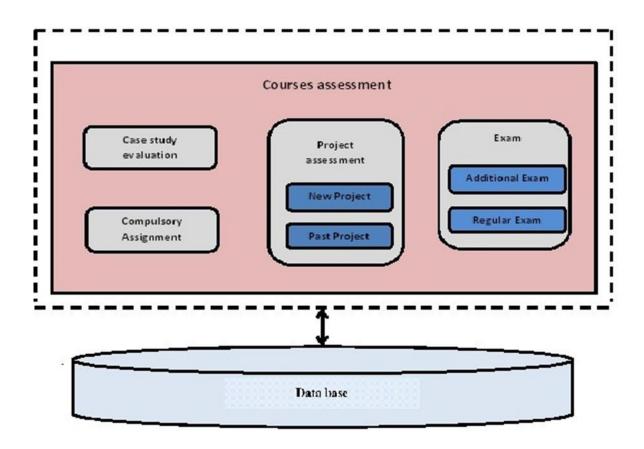


Figure 5.10: Courses assessment

# Chapter 6

# Data Analysis and Findings

This Chapter introduces the objectives of the experimental phase of the proposed e-learning user interface, the hypotheses and outcomes. As well, it presents an illustrative and descriptive analysis of the data collection. The results are discussed in the context of the hypotheses.

#### 6.1 Presentation of Results

Statistical methods and techniques are used to collect, analyze, interpret and present data [51]. Two quantitative surveys were used to collect information about the usability of the D2L elearning user interface at Laurentian University and the proposed e-learning user interface with streaming media for visually and hearing impaired students. Several interrelated procedures were performed during the data analysis stage. SPSS version 20 has been used to tabulate and analyze the valid responses. At the beginning, a comprehensive data file was created. Variables and their labels were then defined. A few statistical tools such as descriptive, Paired samples T- Tests were used in the following scenarios for the analysis.

#### 6.1.1 Descriptive

The main goal of this study is to integrate the tools for visually- and hearing- impaired students in an existing e-learning system like D2L without using any assistive software technology to help them to use and understand the tasks in the e-learning system. In addition to answer the question "Does D2L at Laurentian University meet the needs of visually- and hearing- impaired students?" we test the following null hypothesis (H0) to try to prove our claim and question:

H0: There is no difference in the mean satisfaction of visually- and hearing- impaired students between D2L user interface and the proposed e-learning user interface.

H1: there is a difference in the mean satisfaction of visually- and hearing- impaired students between the D2L user interface and the proposed e-learning user interface.

To test the above hypothesis, descriptive statistics have been used to label and describe some of the results from both questionnaires: D2L user interface questionnaires (QDUI) and suggested elearning user interface (QNEUI) for visually- and hearing- impaired students at Laurentian University to see the differences between both systems. The factors are summarized in the both surveys as follows: accessibility for user interface, clarity of commands, ease of use of the interface, design and Streaming media effectiveness, readability of texts and webpages, useful for special needs students and satisfaction of user interface (view table 6.1). Descriptive statistics are shown in Table 6.1 to give the mean of answers of each factor between the two user interfaces (LD2L and ELUI) for visually- and hearing- impaired students. From Figure 6.1, it can be seen there is a big difference in the participant satisfaction between the proposed user interface and the D2L user interface for students with visual and hearing impairments by looking at the averages of all the participants' answers for each factor that describes the extent of participant satisfaction.

	SysType1	N	Mean	Std. Deviation	Std. Error Mean
A 11.11.	ELUI	5	4.4000	0.54772	0.24495
Accessibility	LD2L	5	2.6000	0.89443	0.40000
	ELUI	5	4.6000	0.54772	0.24495
Clearly	LD2L	5	1.8000	0.83666	0.37417
East of used	ELUI	5	4.8000	0.44721	0.20000
Easy of used	LD2L	5	1.6000	0.54772	0.24495
Design	ELUI	5	5.0000	0.00000	0.00000
effectiveness	LD2L	5	2.4000	1.51658	0.67823
Streaming	ELUI	5	4.6000	0.54772	0.24495
media effectiveness	LD2L	5	2.4000	0.89443	0.40000
Readability	ELUI	5	4.8000	0.44721	0.20000
webpages	LD2L	5	1.8000	1.30384	0.58310
Readability	ELUI	5	5.0000	0.00000	0.00000
of texts	LD2L	5	2.0000	1.22474	0.54772
Useful for	ELUI	5	4.6000	0.54772	0.24495
accessibility	LD2L	5	1.8000	0.83666	0.37417
Satisfaction	ELUI	5	4.6000	0.54772	0.24495
Saustaction	LD2L	5	1.8000	0.83666	0.37417

 Table 6.1: Descriptive statistics of visually- and hearing-impaired students' answers for each factor in both surveys

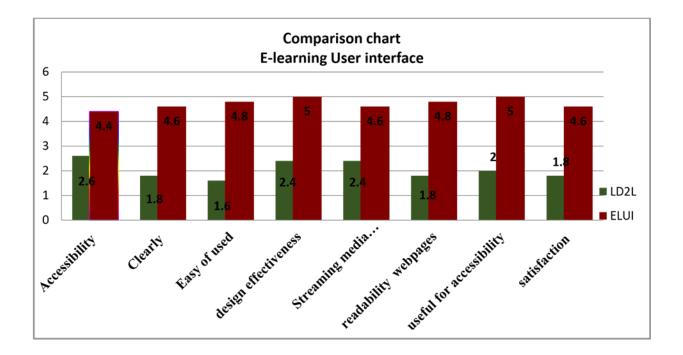


Figure 6.1: Differences between factors when using D2L e-learning user interface and proposed elearning user interface.

#### **6.1.2 Paired samples T-test**

In addition, to answer the second question in chapter 1 "Does the measure of usability testing (Factors) based on the existing e-learning system differ with the suggested e-learning system user interface?" this study will use Paired samples T-test, a feasible test with a small sample size (N=5). The test will be for each usability factor as one sample experiment is on two user interfaces. Compared to the usability testing factors, the hypothesis tends to predict the statistical power of comparing the mean scores between LD2L and ELUI for visually-and hearing- impaired students. The usability factors tested in this study are at the satisfaction level of both user interfaces, ease of use for both user interfaces by visually-and hearing students, clarity of commands and accessibility for user interfaces. So the following are all paired sample statistical analysis for those factors:

#### ➤ Satisfaction level :

H0: There are statistically no significant differences between the mean of satisfaction level for visually- and -hearing impaired students when they use both user interfaces.

*H0:* 
$$\mu d = 0$$
 ,  $\mu d = \mu 1 - \mu 2$ 

H1: There are statistically significant differences between the mean of satisfaction level for visually- and -hearing impaired student when they use both user interfaces. H1:  $\mu d = \mu 1 - \mu 2 < 0$ 

Paired Samples Statistics

Failed Samples Statistics									
			Mean	Ν	Std. Deviation	n Std. Err	or Mean	1	
	Pair 1	LD2L	1.8000	5	0.83666	0.37417	7		
	rall 1	ELUI	4.6000	5	0.54772	0.24495	5		
			Pair	ed Sam	ples Test				
			Pair	red Diff	erences				
					1				
		Mean	Std. Deviation	Std. Error Mean	Interva Diffe	nfidence Il of the prence	t	df	Sig. (1tailed)
				Wiean	Lower	Upper			
Pair 1 LD2I	L - ELUI	-2.80000	1.09545	.48990	) -4.16017	-1.43983	-5.715	4	0.002

Table 6.2: Paired Samples T test for satisfaction level

From above data in the Table 6.2 we can calculate probability of one-tailed (note that a one-tailed test has more power than a two-tailed test), the P - value is equal to 0.002, so P-value is less than 0.05. It can be concluded that there are statistically significant differences between the mean of satisfaction level for visually-and-hearing students when they use LD2L user interface and the proposed e-learning user interface (ELUI). Since the Paired Samples Statistics box revealed that the mean satisfaction level of students for the proposed e-learning user interface was greater than the mean for the D2L user interface, it can be concluded that students' satisfaction level increased significantly when they used the proposed e-learning user interface (ELUI) compared to their satisfaction level when they used D2L. As a result of this analysis, we reject the null hypothesis

(H0), and accept the alternative hypothesis (H1). That means that there are statistically significant differences between the mean satisfaction levels for visually- and-hearing impaired students when they use both user interfaces.

#### **Ease of use UI**

H0: There are statistically no significant differences between the mean of ease of use for visuallyand-hearing impaired students for D2L interface and proposed e-learning user interface (ELUI).

*H0*: 
$$\mu d = \mu 2 \cdot \mu l = 0$$

H1: There are statistically significant differences between the mean of ease of use for visually and-hearing impaired students for D2L interface and proposed e-learning user interface (ELUI).

*H1:* 
$$\mu d = \mu 2 \cdot \mu l > 0$$

Table 6.3: Paired Samples T-test for Ease of use UI

_	Paired Samples Statistics						
	-	Mean	N	Std. Deviation	Std. Error Mean		
Pair 1	LD2L ELUI	1.6000 4.8000	5 5	0.54772 0.44721	0. 24495 0. 20000		

	Paired Samples Test Paired Differences							
	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference		t	df	Sig. (1tailed)
			Mean	Lower	Upper			
Pair 1 ELUI -LD2L	3.200	0.447	0.200	2.64471	3.75529	16.000	4	0.001

Paired Samp	oles Test
-------------	-----------

As shown in Table 6.3 we can see t (4) = 16.000, p = 0.001 (one -tailed), so p-value < 0.05, that means there are statistically significant differences between the mean of ease of use for visually and-hearing impaired students for D2L interface and proposed e-learning user interface(ELUI). Paired samples statistics box shows that the mean of ease of use UI of students when they used D2L user interface was less than the mean when they used proposed e-learning user interface. In addition ease of use UI increased significantly when visually-and-hearing impaired used the proposed e-learning user interface (ELUI) compared to their ease of use UI when they used D2L. As a result for this analysis, we reject the null hypothesis (H0), and accept the alternative hypothesis (H1). That means there are statistically significant differences between the mean of ease of use for visually-and-hearing impaired students for D2L interface and proposed e-learning user interface (ELUI).

- ➢ Clarity of commands in the UI:
- H0: There are statistically no significant differences between the mean of clarity of commands in the D2L interface and the ELUI interface for visually-and-hearing impaired students.

*H0:* 
$$\mu d = \mu 1 - \mu 2 = 0$$
 ,  $d = \mu 1 - \mu 2$ 

H1: There are statistically significant differences between the mean of clarity of commands in the D2L interface and the ELUI interface for visually-and-hearing impaired students.

*H1:* 
$$\mu d = \mu 1 - \mu 2 < 0$$

Table 6.4: Paired Samples T-test for clarity of commands in the UI

i alled Samples Statistics								
		Mean	N	Std. Deviation	Std. Error Mean			
Pair 1	LD2L	1.8000	5	0.83666	0.37417 0.24495			
rall I	ELUI	4.6000	5	0.54772				

Paired Samples Statistics

Paired Samples Test	
---------------------	--

		Pair	red Differe	ences				
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (1tailed)
			Mean	Lower	Upper			
Pair 1 LD2L - ELUI	-2.80000	0.44721	0.20000	-3.35529	-2.24471	-14.000	4	0.0001

From paired sample t- test we calculate p-value t (4) = -14.000 see (table 6.4) p-value = 0.0001, then p-value < 0.05, as a result of this analysis, we reject the null hypothesis (H0), and accept the alternative hypothesis (H1). So there are statistically significant differences between the mean of clarity of commands in the D2L interface and the ELUI interface for visually-and-hearing impaired students, and the mean of clarity of commands in the UI for the proposed e-learning user interface (ELUI) was greater than the mean for the D2L user interface as shown in Table 5.4.

#### Accessibility for user interfaces

H0: There are statistically no significant differences between the mean of accessibility for the D2L interface and the proposed e-learning user interface (ELUI)

*H0:* 
$$\mu d = \mu 1 - \mu 2 = 0$$

H1: There are statistically significant differences between the mean of accessibility for the D2L interface and the proposed e-learning user interface (ELUI)

*H1:* 
$$\mu d < 0$$

Table 6.5: Paired Samples T-test for accessibility for user interfaces.

Paired Samples S	tatistics
------------------	-----------

			Mean	Ν	Std. Deviation	n Std. Err	or Mean		
	Pair 1	LD2L ELUI	2.6000 4.4000	5 5	0.89443 0.54772		40000 24495		
			Pair	ed San	ples Test				
			Pair	ed Diff	erences				
		Mean Std. Deviation		Std. Erroi Mear	· Interva Diffe	95% Confidence Interval of the Difference		df	Sig. (1tailed)
				Mea	Lower	Upper			
Pair 1 LD2I	- ELUI	-1.80000	0.44721	0.200	00 -2.35529	-1.24471	-9.000	4	0. 001

From the above data in Table 6.5, the p-value is equal 0.001, so the p-value is less than 0.05 because of that we reject null hypothesis (H0) and accept the alternative hypothesis (H1). That means there are statistically significant differences between the mean of accessibility for the D2L interface and the proposed e-learning user interface (ELUI).

Finally, all usability factors have similar results; that means that there are statistically significant differences between the mean of factors (Design effectiveness, Streaming media effectiveness, Readability webpages, Useful for accessibility, Readability of texts) in the D2L interface and the proposed e-learning user interface (ELUI) for visually-and-hearing impaired students.

#### 6.2 Time of tasks completion

Time accuracy is another measure of usability methods. The time spent by the participants on each task or navigation of the proposed e-learning user interface and for the D2L user interface is shown in Table 6.6. A program was developed to calculate the time that it takes to finish the tasks in the proposed e-learning user interface. For the D2L user interface, the time was recorded by using a mobile phone timer (see table 6.6).

Both user interfaces were tested by the participants, and the execution speed of each task was compared for the two interfaces.

The speed of the following tasks was recorded to measure the usability testing. Average time for each task is given below.

Navigation for both e-learning user interfaces;

Participants were asked to navigate the proposed e-learning user interface, and the time to navigate was recorded for all participants. Average time spent on the proposed e-learning

user interface was  $\mu$ = 5 seconds and on the D2L user interface it was  $\mu$ = 10.06 seconds.

#### Read tool bar on both user interfaces.

The time spent to read the tool bar in the proposed e-learning user interface was  $\mu$ = 2.08 seconds and on the D2L user interface it was  $\mu$ =33 seconds.

#### ➢ Upload file

In this task, the time was recorded when the participants press the upload file command. That means the time to upload the file is not calculated. The average time on the proposed e-learning user interface to upload file was  $\mu$ =2.08 seconds and on the D2L user interface was  $\mu$ = 46 seconds.

#### Read a paragraph:

In this task the participants had to read a paragraph by listening to the voice, tap or read a paragraph by having the ability to control the font size. In the proposed user interface the average time they spent was  $\mu$ = 4.04 seconds for reading, and  $\mu$ = 60 seconds on D2L e-learning user interface.

#### ➢ Viewing grades.

The time was calculated when the participants start to view their grades. The average time that participants spent on the proposed e-learning user interface was  $\mu$ =2.06 seconds, and on the D2L was  $\mu$ =45seconds.

#### Viewing a chart.

In this task, the average time that was spent on the proposed e-learning user interface

to explain a chart by voice or sign language was  $\mu$ =3. 2 seconds, and on the D2L it was  $\mu$ =60 seconds.

 $\succ$  Watch the video.

In the proposed e-learning user interface, the average time to view streaming video was  $\mu$ = 26second, but this task was not available on the D2L so the average time was  $\mu$ =0.

Table 6.6: Average time (in seconds) to accomplish tasks.

Tasks	Time to finish the tasks on D2L user interface	Time to finish the tasks on the new user interface.
Navigation	10.6	5
Read tool bar	33	2.08
Upload file	46	2.08
Read paragraph	60	4.04
Viewing grades	45	2.06
Viewing chart	60	3.02
Watch the video	N/A	26

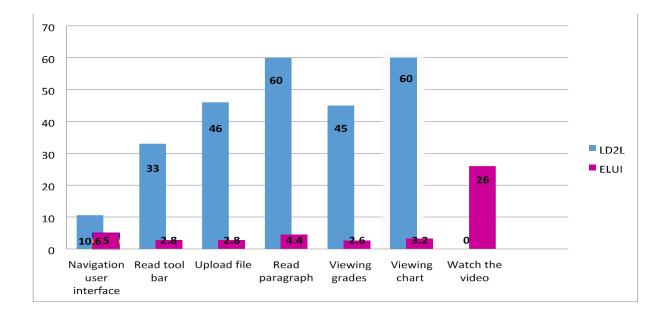


Figure 6.2: Bar chart showing the average time (in seconds) to accomplish tasks.

Figure 6.2 shows the great disparity in the time consumed by the participants to accomplish tasks between the D2L system and the proposed user interface for visual and hearing impaired students. The chart shows that the participants found the ease of use and greater speed in completing tasks when they used the proposed e-learning user interface.

## Chapter 7

## Conclusions and Future Work

This study has tried to highlight the most important obstacles faced by students with visual and hearing impairment in the university using the D2L e-learning system which does not support tools for such students on the user interface. Students were taken from the Laurentian University as an example for this study. Based on the needs of the visual and hearing impaired students a user interface was designed for e-learning and a usability testing method was used to prove their satisfaction and ease of use of the user interface.

#### 7.1 Conclusion

The new e-learning user interface has many features and tools that enable the students with visual and hearing impairment to use the e-learning system without the use of any assistive technology. Some of these tools are expected to contribute and help those students to use e-learning system. For example, the features involved are: commands to read with voice, Tab voice, voice reading for web page, sign language for commands and uploading video and audio with sign language on the user interface, zoom texts, and control of colour of font and background. All these features have been implemented and tested in the new user interface. From statistical analysis we infer that there are big differences in the usability testing factors between the D2L user interface and the new user interface for participants tested at Laurentian University. In addition, the paired sample T- Test showed that the hearing and visually impaired students are not satisfied with the existing D2L e-learning system and satisfied with the new designed user interface for participants to use the same environment as other students, which achieved the main goal of this study. Finally, the time accuracy method to measure the usability testing also found that the proposed user interface

is easy to use, and is speedy in completing tasks. We can conclude that visually-and hearingimpaired students who participated in this study have been completely satisfied with this new user interface design.

#### 7.2 Recommendations

This study explored the most important obstacles that are faced by students with special needs, when they use an e-learning system. Based on the study following recommends are suggested.

• Conducting more studies, actively involving more special needs students with their teachers, and reflecting design perspectives from teaching practice using this suggested Interface for future development.

• An IT Developer should review the existing e- learning system not only as a tool for teaching but also as a system that provides the available smart technology that can be used equally by the special needs students.

• Investigate the academic e-learning barriers of special needs students within more organizations in order to increase understanding of their needs and match them to the available smart technology.

• Design the e-learning systems for special needs students by considering the instructional strategies available for them.

• Provide all possible tools features and format such as audio, video, sign languages, converter for text from any language to their readable language, training material, etc. This would allow them to select the tool that best fits their needs.

• Provide faculty training in special needs tool. For example, how they can translate their lectures through streaming technology by using sign language for lessons, tests, assignments and so on. This will confirm that they are completely aware of the barriers that visually and hearing impaired students face.

• Finally, based on the participants' interview, the designer and developer for the e-learning system should consider the students' needs and ability level. For example, allow color ant text customization based on their ability. One of the participants asked for black background and white print but another one asked for the opposite. Allowing students to modify the colors and the text size of the elements will make it easier for them in their learning process.

#### 7.3 Recommendations for Future Research

The user interface design developed in this study is at a very early stage of understanding the requirements for the special needs students and what is best for them, especially those with hearing and visual problems. To continue improving the e-learning system design for special needs students, four recommendations for future research follow:

1. Repeat this study with more participants and in more universities, specifically those universities that have a complete and open source learning system to link the new developed user interface directly with this system and test those students on it.

2. Study an e-learning system with special needs students in different contexts or setting for example, make a systematic review of an accessible e-learning websites without using assistive technology, and integrate them in the existing one.

3. Identify the best academic strategies that support the e-learning for students who regularly work on assistive technology.

And,

4. Designing a standard methodology as a guideline that has features to develop e-learning systems for students with special needs.

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# Appendix A: Approved Ethics Certificate



#### APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL / New X	/ Modifications to project / Time extension
Name of Principal Investigator and school/department	Wejdan Farhan (Math and Computer Science) Kalpdrum Passi (Supervisor, Math and Computer Science)
Title of Project	E-Learning Tools for Students with Hearing and Vision Impairment
REB file number	2013-12-08
Date of original approval of project	March 5, 2014
Date of approval of project modifications or extension <i>(if applicable)</i>	
Final/Interim report due on	March 5, 2015
Conditions placed on project	Final report due on March 5, 2015

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate REB form.

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate REB form. In all cases, please ensure that your research complies with Tri-Council Policy Statement (TCPS). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best of luck in conducting your research.

- Suran James

Susan James, Chair Laurentian University Research Ethics Board

#### **Consent form:**



#### CONSENT TO PARTICIPATE IN RESEARCH

You are asked to participate in a research study conducted by Wejdan Farhan under the supervision of Dr. Kalpdrum Passi from the Department of Mathematics and Computer Science at Laurentian university.

If you have any questions or concerns about the research, please feel free to contact

Wejdan Farhan: wfarhan@laurentian.ca

Dr. Kalpdrum Passi: kpassi@cs.laurentian.ca, Phone no: 705-675-1151 ext: 2345

#### **PURPOSE OF THE STUDY**:

The purpose of the study is to test the efficiency and ease of use of the web-based tools on the elearning system for students with hearing and vision impairment.

#### **PROCEDURES:**

If you volunteer to participant in this study, we would ask you to do the following things:

- 1. Explore and navigate the e-learning system through the user interface that includes certain tools for students with hearing and vision impairment.
- 2. Evaluate the usability testing for the e-learning system through the user interface by completing a survey. You can indicate the ease of use for each design on a Likert scale.
- 3. The study length is 15 minutes: five minutes for exploring the user interface design and 10 minutes for filling the survey.

#### POTENTIAL RISKS AND DISCOMFORTS

There are no risks or discomforts associated with the survey. There is no probability of possible harm. The methods have no psychological or health-related side effects and do not cause discomfort. You can withdraw from the study if there is a feeling of discomfort or stress. You can rejoin in the study if you are interested.

#### POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

There are no direct or recent benefits other than learning about the interface design of an elearning system and its direct application. The future potential benefits to the research community include development of e-learning techniques for special needs students and integrating them with the existing e-learning systems.

#### PAYMENT FOR PARTICIPATION

There will be no payment to participate in the survey.

#### CONFIDENTIALITY

The survey will not require any personal and confidential information. Only aggregate results of the usability testing of the developed user interface will be collected to improve the eLearning system (for students with special needs).

#### DATA STORAGE

The completed surveys will be kept in a secure cabinet in a locked office. Survey data that will be obtained from the participants will be maintained until the study's completion. The data will be analyzed and stored in a secure file. Access to computer files will be password protected. All data sheets will be shredded after the completion of the study. Only aggregate results will be stored.

#### PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may exercise the option of removing your data from the study. You may also refuse to answer any questions you don't want to answer and still remain in the study.

#### RESULTS

Please fill your contact information if you are interested in knowing the results of your participation. I will contact you after the results have been finalized.

**ISSUES / ETHICAL CONCERNS** For any issues with the current study or ethical concerns on the research, students can contact **Research Ethics Officer**, Laurentian University Research Office, telephone: 705-675-1151 ext 2436 or toll free at 1-800-461-4030 or email: ethics@laurentian.ca

#### SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided for the study "E-Learning Tools for Students with Hearing and Vision Impairment" as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

\_\_\_\_\_ Name

of Participant (please print)

Signature of Participant

Date

#### INTERESTED PARTICIPANT INFORMATION FOR GETTING RESULTS AT THE STUDY

E-MAIL ID

# Appendix B:

# Survey for both e- learning user interfaces

No	Question / statement	Answer / options				
	User Interface Usability	Strongly disagree	Disagre e	Neith er	Agree	Strongly agree
1	The D2L user interface allows easy access to information.					
2	In D2L user interface the configuration of commands and background are clear and harmonious (for students with visual and hearing impairments).					
3	The button command in D2l user interface is clear and easy to use (for those who have vision and hearing impairments).					
4	The screen layout and design in D2L user interface are appropriate (for students with visual and hearing impairments).					
5	When I reviewing media with audio and video in D2L user interface be very clear (for students with visual and hearing impairments).					
6	The ability to read the webpages in D2L user interface. (For students with visual and hearing impairments).					
7	The ability to read text and objects in D2L user interface is very easy (for students with visual and hearing impairments).					
8	I do not experience problems using the accessibility commands in D2L user interface.					
9	I think the D2L user interface designed for all levels of users.					
10	I am satisfied with D2L user interface .					

### Survey of designed user interface (suggested)

No	Question / statement	Answer / options				
	User Interface Usability	Strongly disagree	Disagre e	Neither	Agree	Strongly agree
1	The e-learning user interface allows easy access to information.					
2	The configuration of voice commands, voice tabs, voice reading and background are clear and harmonious (for students with visual and hearing impairments).					
3	The button voice command with sign language is clear and easy to use (for those who have vision and hearing impairments).					
4	The screen layout and design are appropriate (for students with visual and hearing impairments).					
5	The streaming media with audio and video and sign language are clear (for students with visual and hearing impairments).					
6	The ability to read the webpages improved (for students with visual and hearing impairments).					
7	The ability to maximize and minimize the text and objects is improved (for students with visual and hearing impairments).					
8	I do not experience problems using the accessibility commands in the e-learning user interface.					
9	I am satisfied with this user interface					

# Appendix C Timeline of design new e- Learning user interface:

• Looking at Laurentian University eLearning style and finding initial template	4 h.
Rebuilding new design template	5 h.
Adding sample text-to-speech	3 h.
Adding actions when clicking and hovering	4 h.
• Finding and designing deaf signs using flash and adding it to the actions	
	8 h.
Adding certain data and converting it to speech	3 h.
• Adding grades example and building table design	5 h.
• Adding time counting on mouse and tab events with design changing	
	5 h.
Adding chart and steaming media	2 h.
Changing style of navigation menu	1 h.
Rebuild time counting functions	1 h.

# Appendix D: New E-learning User Interface Code

To implement the new e-learning user interface, the following was used:

1- Wamp Server by using PHP

- 2- Hyper Text Mark-up Language (HTML)
- 3- JavaScript library

4- SWF (Small Web Format) The file format for playing Flash animation files (Flash movies).

5- Cascading Style Sheet (CSS)

- 6- Adobe Flash Professional (for sign language)
- 7- Natural Reader: to change the text to audio.( save file Wav) 8- Notepad++ and

Adobe Dreamweaver: to edit the scripts on pages.

9- http://freehtml5templates.com: help of template and modified.

10- http://stackoverflow.com/, and http://www.youtube.com/ : for search of sign language.

The code is given below.

<html lang="en">

<head>

<meta charset="utf-8" />

<title>E-Learning</title>

k rel="stylesheet" href="css/styles.css" type="text/css" media="screen" />

k rel="stylesheet" href="css/custom.css" type="text/css" media="screen" />

<script type="text/javascript" src="js/jquery-2.1.0.js"></script>

```
<script type="text/javascript" src="js/custom.js"></script>
<style type="text/css" media="screen"> h1.fontface {
font: 32px/38px 'MichromaRegular', Arial, sans-serif;
letter-spacing: 0;
}
```

p.style1 { font: 18px/27px 'MichromaRegular', Arial, sans-serif;

}

@font-face { font-family: 'MichromaRegular'; src: url('Michroma-webfont.eot'); src:

url('Michroma-webfont.eot?#iefix') format('embedded-opentype'),

url('Michromawebfont.woff') format('woff'), url('Michroma-webfont.ttf') format('truetype'),

url('Michromawebfont.svg#MichromaRegular') format('svg'); font-weight: normal; fontstyle: normal;

}

</style>

</head>

<body>

<header>

```
<div class="container1">
```

<h1 class="fontface" id="title">E-learning</h1>

</div>

</header>

<nav>

<div class="menu">

<li id="myhome"

```
onMouseOver="navOn(this.id);"
```

```
onMouseOut="navOff(this.id);">
```

```
<a tabindex="1" onFocus="navOn(parentNode.id);"
```

```
onFocusOut="navOff(parentNode.id);"
```

```
id="myhomelink" href="index.php">My Home</a>
```

```
<object id="myhomeswf" align="top" style="display:none;margin-top:-
```

50px;"

```
type="application/x-shockwave-flash"
```

```
data="swf_signs/nav/myhome.swf" width="80" height="110">
```

```
<param name="wmode" value="transparent" />
```

</object>

id="contents"

```
onMouseOver="navOn(this.id);"
```

```
onMouseOut="navOff(this.id);">
```

<a tabindex="2" onFocus="navOn(parentNode.id);"

onFocusOut="navOff(parentNode.id);"

id="contentslink" href="contents.php">Contents</a>

<object id="contentsswf" align="top"

style="display:none;margin-top:-50px;" type="application/x-shockwave-flash"

data="swf\_signs/nav/contents.swf" width="80" height="110">

<param name="wmode" value="transparent" />

</object>

```
id="dropbox"
```

```
onMouseOver="navOn(this.id);"
```

```
onMouseOut="navOff(this.id);">
```

<a tabindex="3" onFocus="navOn(parentNode.id);"

onFocusOut="navOff(parentNode.id);"

id="dropboxlink" href="dropbox.php">Dropbox</a>

<object id="dropboxswf" align="top"

style="display:none;margin-top:-50px;"

```
type="application/x-shockwave-flash" data="swf_signs/nav/dropbox.swf" width="80"
```

height="110">

<param name="wmode" value="transparent" />

</object>

id="grades"

```
onMouseOver="navOn(this.id);"
```

```
onMouseOut="navOff(this.id);">
```

<a tabindex="4" onFocus="navOn(parentNode.id);"

onFocusOut="navOff(parentNode.id);"

id="gradeslink" href="grades.php">Grades</a>

<object id="gradesswf" align="top"

style="display:none;margin-top:-50px;"

type="application/x-shockwave-flash" data="swf\_signs/nav/grades.swf" width="80"

height="110">

<param name="wmode" value="transparent" />

</object>

</div>

</nav>

<div id="wrapper">

<section id="main">

<aside id="sidebar1">

<h3>Other Links</h3>

a href="#">Bookmarks</a>

<a href="#">Upcoming Events</a>

a href="#">Table of Contents</a>

<div class="options">

Font Size

<a

href="javascript:changefontsize('decrease');"

style="fontsize:12px;">Small</a>

<a href="javascript:changefontsize('reset');" style="font-size:16px;">Default</a>

<a href="javascript:changefontsize('increase');" style="fontsize:20px;">Large</a>

Font Color

<a href="javascript:changefontcolor('white');">White</a>

<a href="javascript:changefontcolor('black');">Black</a>

<a href="javascript:changefontcolor('red');">Red</a>

<a href="javascript:changefontcolor('green');">Green</a>

#### 

<a href="javascript:changefontcolor('yellow');">Yellow</a>

<a href="javascript:changefontcolor('orange');">Orange</a>

<a href="javascript:changefontcolor('blue');">Blue</a>

<a href="javascript:changefontcolor('pink');">Pink</a>

Background Color

><a href="javascript:changebackgroundcolor('white');">White</a>

<a href="javascript:changebackgroundcolor('black');">Black</a>

<a href="javascript:changebackgroundcolor('red');">Red</a>

<a href="javascript:changebackgroundcolor('green');">Green</a>

<a href="javascript:changebackgroundcolor('yellow');">Yellow</a>

<a href="javascript:changebackgroundcolor('orange');">Orange</a>

<a href="javascript:changebackgroundcolor('blue');">Blue</a>

<a href="javascript:changebackgroundcolor('pink');">Pink</a>

</div>

<span id="dummy"></span> </aside>

<section id="content">

<article id="article" class="group2" style="font-size:16px;"><h1>Article Title</h1>

<p

onMouseOut=playSound(");>

<a href="tabindex='6' onFocus=playSound('voices/paragraph/laurentian\_goes.wav'); onFocusOut=playSound("); >Laurentian goes to great lengths to ensure personal success by providing a range of academic and social supports for our diverse student population, ensuring our students acquire a strong foundation that meets the challenges and opportunities of the 21st century.</a>

```
<img
                   src="images/image1.jpg"
                                                     alt="University
                                                                              images"
style="width:650px;height:500px;"/>
<img
                   src="images/image2.jpg"
                                                     alt="University
                                                                              images"
style="width:650px;height:500px;"/>
<img
                   src="images/image3.jpg"
                                                     alt="University
                                                                              images"
style="width:650px;height:500px;"/>
   </article>
    </section>
 </section>
  </div>
<footer>
   <div class="container1">
  <section id="footer-area">
     <section id="footer-outer-block">
    © 2014 E-learning
   </section>
```

```
</section>
```

```
<!-- end of footer-area -->
```

```
</div>
```

```
</footer>
```

```
</body>
```

```
</html>
```

```
The function that used in source code are : var count =
```

```
1; // defining count as counter_base var counter = "";
```

```
//defining counter as counter variable function timer()
```

```
{
```

```
1;
       count=count
                                               +
       document.getElementById("timer").innerHTML=count + " secs";
} function beginCount
0
{
       count = 1;
       counter = setInterval(timer, 1000);
       }
function stopCount ()
{
              clearInterval(counter);
              count = 1;
                     function
}
playSound(soundfile)
```

{ stopCount(); // calling stopCount function if (soundfile !=

")beginCount(); // calling beginCount function // start playing

the sound and place it into "dummy html tag"

document.getElementById("dummy").innerHTML =

'<audio autoplay id="audiofiles"><source src="'+soundfile+'" type="audio/wav"></audio>';

```
} function navOn
```

(value)

{ var id = value + "swf" ; var element =

document.getElementById(id) ;

// calling playSound function playSound('voices/nav/'

+ value + '.wav') ; element.style.display = 'inline' ;

```
var id = value + "link" ; var element =
```

document.getElementById(id);

element.style.fontSize = '28px';

```
element.style.marginRight='0px';
```

```
} function navOff
```

(value)

{ var element = document.getElementById(value +

'swf'); playSound('');

```
element.style.display = 'none'; var id =
```

```
value + "link"; var element =
```

document.getElementById(id);

element.style.fontSize = '26px';

element.style.marginRight='50px';

```
function
}
graphOn(value)
{ var element =
document.getElementById('swf_alternative');
       playSound('voices/graph/' + value + '.wav');
       element.style.display = 'inline';
                                           element.data =
'swf_signs/graph/' + value + '.swf';
           function
}
graphOff()
{ var element =
document.getElementById('swf_alternative') ; playSound(")
; element.style.display = 'none';
                       function
}
changefontcolor(color)
{
       var elm = document.getElementById("article") ;
       elm.style.color = color ;
       createCookie ("fontcolor",color);
}
                              function
changebackgroundcolor(color)
{
              var elm = document.getElementById("article");
       elm.style.backgroundColor = color ;
       createCookie ("backgroundcolor", color);
```

#### } function

```
changefontsize(size)
{
              var elm = document.getElementById("article");
       var s = elm.style.fontSize ; s = s.replace("px","") ;
       if (size == 'increase')
       {
              s -=1 ;
              s += 5;
       } else if (size ==
       'reset')
              s = 16;
       else if (size == 'decrease')
       {
              s -=4 ;
              if (s <= 3) s = 16;
       }
       elm.style.fontSize = s + "px" ;
       createCookie ("fontsize", s+"px");
}
$( document ).ready(function() {
```

```
var elm = document.getElementById("article") ;
```

```
elm.style.fontSize = getCookie('fontsize'); elm.style.color
```

```
= getCookie('fontcolor'); elm.style.backgroundColor =
getCookie('backgroundcolor');
}); function createCookie (name,
value)
{
    expires = "; expires=Fri, 29 Dec 2015 12:00:00 GMT" ;
document.cookie = name + "=" + value + expires + "; ";
} function getCookie(c_name) { if (document.cookie.length > 0) {
    c_start = document.cookie.indexOf(c_name + "="); if (c_start != -
1) {
```

```
c_start = c_start + c_name.length + 1;
```

c\_end = document.cookie.indexOf(";", c\_start);

if (c\_end == -1) { c\_end =

document.cookie.length;

}

return unescape(document.cookie.substring(c\_start, c\_end));