E-learning User Interface For Visual and Hearing Impaired Students

Wejdan Farhan and Kalpdrum Passi
Department of Mathematics & Computer Science, Laurentian University, Sudbury, Canada

Abstract - This paper 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 paper the tools and features in the user interface required for making the learning process easy and effective for students with such disabilities have been presented. The tools and features added to the user interface were tested with visually and hearing impaired students from Laurentian University’s population. 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.

Keywords: E-learning; visually and hearing impaired; D2L user interface.

1 Introduction

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 [1, 3, 11, 15] 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 [17]. 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 [10, 20]. 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 [20, 24]. 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 [24].

This paper 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. 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.

2 Related Work

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.

Visual Impairment

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” [21]. Firstly, in the research literature, of all the different special needs scenarios, blind users show the most complications when performing a task [5, 9, 13, 21]. 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. The frustrations of blind and low vision people 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 [7]. 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 [3]. 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.

**Hearing Impairement**

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 e-learning 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 [2]. Parton [18] 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 e-learning layout. Richardson et al. [21] in their study mention that communication was easier in e-learning 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 [12].

### 3 Prototype Design for E-Learning User Interface

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 [16] 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. 1 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.

**Choose alternatives**

After interviewing visually and hearing impaired students two alternative e-learning user interfaces were designed. 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 Home, Course Home, Contents, Drop box, and Grades. For example visually and hearing impaired students can use a mouse or tap the bottom of the keyboard to

1http://www.reading.ac.uk/web/FILES/simplification/lucidmarksarkbarratt.pdf
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 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.

4 Implementation of the E-Learning User Interface

This section 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.

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 [6]. As well, Darejeh and Singh [6] 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 [14]. 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 [4, 25]. In [26] 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 [23]. 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 [8].

D2L E-learning System

Listening to the perceptions of visually and hearing impaired students about the D2L (see figure 1) e-learning system at the Laurentian University [12] 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. 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.

Implementing the proposed design of the user interface:

Figure 2 shows the user interface design for the e-learning system that was selected by visually and hearing impaired students through the interviews and questionnaires. Internet websites application languages were used to implement the e-learning user interface.

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 students 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 3).

Figure 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).

Figure 4. Control of text zooming

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 5).

Figure 5. Control of Font and background color

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 6).

Figure 6. 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 7).

Figure 7. Streaming media of lecture with translation in sign language

5 Data Analysis and Findings

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 semi-structured 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, ranging from ‘Strongly Disagree’ to ‘Strongly Agree’. The collected data was analyzed.

![Graph showing differences between factors when using D2L e-learning user interface and proposed e-learning user interface](image)

**Figure 8: Differences between factors when using D2L e-learning user interface and proposed e-learning user interface**

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: 

\[ H_0: \text{There is no difference in the mean satisfaction of visually and hearing impaired students between D2L user interface and the proposed e-learning user interface.} \]

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 (LD2L) and suggested e-learning user interface (ELUI) 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. From Figure 8, 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.

**Paired samples T-test**

In addition, to answer the second question “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 used Paired samples T-test, a feasible test with a small sample size (N=5). The test was 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 impaired students, clarity of commands and accessibility for user interfaces. The paired sample statistical analysis showed that there are statistically significant differences between the mean of the factors (satisfaction level, ease of use of UI, clarity of commands in the UI, accessibility for user interface, time of task completion) in the D2L interface and the new interface (ELUI) for visually and hearing impaired students. Figure 9 shows that the participants found the ease of use and greater speed in completing tasks on the proposed user interface as compared to D2L for visual and hearing impaired students.

![Bar chart showing the average time (in seconds) to accomplish tasks](image)

**Figure 9: Bar chart showing the average time (in seconds) to accomplish tasks.**

### 6 Conclusions

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 of this study. The proposed user interface can be integrated with the D2L system and allow those Students 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 hearing-impaired students who participated in this study have been completely satisfied with this new user interface design.

7 References


