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IMPROVING ACCESSIBILITY OF E-LEARNING SYSTEMS FOR VISUALLY IMPAIRED STUDENTS IN SRI LANKA

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Abstract: *Purpose: This study aims to investigate the means to improve the accessibility of e-learning systems for visually impaired students in Sri Lanka. It focuses on addressing the challenges these students face, particularly during the shift to online learning brought about by the pandemic.*

Design: The study builds on the Web Content Accessibility Guidelines (WCAG), utilizing the POUR principles, Perceivable, Operable, Understandable, and Robust as the conceptual framework.

Methodology: A quantitative design was employed to examine the impact of these principles on learner satisfaction.

Approach: The sample consisted of 150 visually impaired students from the Ceylon Deaf and Blind School, selected through purposive sampling.

Findings: The analysis revealed that both the Perceivable and Understandable factors had a positive and significant impact on learner satisfaction. However, the Operable and Robust factors did not show a significant impact, indicating areas that require enhancement.

Originality/Value: This research contributes to the field by providing empirical insights into the accessibility challenges faced by visually impaired students in Sri Lanka. It underscores the need for improvements in e-learning system design, particularly in operability and robustness, to ensure equitable access.

Keywords: *Accessibility, E-learning, Visually Impaired Students, WCAG, POUR Principles, Learner Satisfaction.*

1. Background of the Study

Technology is a fundamental aspect of contemporary society, it significance is prevalent in all industries including the education system. Information Technology cannot be simply dissociated from pedagogical practices and educational progress. The role of technology is critical in our livelihoods that it is vital for students to develop problem-solving, organizational and crucial skills to meet the demands of an increasingly technology-oriented workplace and become fully integrated members of society. Thus, education is heavily influenced by the emergence of new information and

communication technologies. One such development within the field of education is the concept of e-learning. Since the mid-1990s, within the educational sphere, the number of universities or colleges utilized e-learning to provide high school education, degrees, and courses has grown exponentially. E-learning is a learning/teaching approach that may make up all or a portion of the educational model adopted. It substantiates on the use of electronic devices and media to improve access to interactions and discussions that facilitate the establishment of a new way of learning and comprehending. Accordingly, e-learning has a direct relationship with novel technologies which support the concept of online learning platforms as a conducive means to improving the accessibility of education in terms of providing instruction where students can access wherever and whenever they want. Additionally, it is hoped that students who cannot attend formal education will be able to complete their programs with the aid of remote learning programs. Therefore, it can be claimed that the concept of distant learning is to make education more accessible. However, there are also concerns about how accessible online learning settings are for students with disabilities. (Burgstahler, 2004) assert that the ultimate purpose of distance learning to make education accessible to everyone which cannot be simply achieved unless the course design is inclusive of all students, including those with disabilities. However, accessibility is rarely a top consideration for those who create online courses, and those who have impairments are not thought of as a significant category of students (Treviranus, 2006). Visually impaired students or learning system users are a group that has the greatest barriers to accessing and utilizing educational technologies. Statistics show that there are more blind students enrolling in schools and universities each year, but technological advancements have not kept up. The Ceylon School for the Deaf and Blind (CSDB) was established in the year 1912 with the objective of making education accessible for the disabled students particularly with hearing and sight impairments (Padmasiri, S., 2013). Around 1.7% of Sri Lankans are blind approximating to 364,000 people being blind. Thus addressing the socio-economic needs of the blind is an important factor given the considerable numbers. There are approximately 600 students currently enrolled at the CSDB (Padmasiri, S., 2013). However, these students were significantly challenged with the onset of the pandemic where remote or e-learning became a prevalent form of education amidst concurrent lockdowns. These e-learning systems are of little relevance to the visually impaired. To avoid a decline in social mobility these inequalities in the education system need to be mitigated (Pendigrast, R., 2021). It is crucial to make sure that those with vulnerabilities can access and use instructional materials, particularly those provided through online learning management systems for equality in education systems. Thus, the purpose of this study is to improve the accessibility of e-learning systems for students with visual impairments. Therefore, the researcher intended to test an online learning management system with learners who are end users of the tool. The outcomes would then generate useful design insight for the development of a suitable e-learning system for the visually impaired in Sri Lanka.

Problem Statement

Online or e-learning has partially contributed to the massification, internationalization, and universalization of education (Karkouti., B., 2021). It has also transformed the concept of learning and teaching mechanisms, student evaluations, and professional development of faculty. With the onset of the pandemic, over 1.6 billion students were subjected to a temporary discontinuation of education (United Nations (UN), 2020), whereby educational institutions had to utilize technology to continue to provide education despite the adversities created by the pandemic. This transition ignited the importance of online education in terms of its accessibility to students. Though the prevalence of online learning in Sri Lanka is unknown, according to (Fazlulhaq, 2021) report,

only 30% of Sri Lankan students were able to migrate to online study during the pandemic. The inclusion of visually impaired students in the e-learning context in Sri Lanka is even more uncertain. Considering that United Nations Sustainable Development Goal number 4 and the accessibility offered by e-learning through ICTs, it may seem that no person willing and able to learn is left behind. The inclusion of visually impaired students (VIS) in online learning, however, has not been acknowledged. The few other related studies (Teklu A.,Samuel A., 2022) focused on the experiences of visually impaired students participating in traditional classroom settings. This is in contrast to a study (Amponsah, 2012) that focuses on the experiences of visually impaired students participating in online learning. Students with visual impairments have been generally disregarded in web-based learning in scholarly research. There is a dearth of research on the pedagogical aspects of course design at the nexus of accessibility and online learning. Moreover, there are little to no studies within the context of Sri Lanka considering the novelty of e-learning. Although web accessibility specifications and related guidelines have been elucidated and examined previously, it is difficult to deduce that these specifications have helped in solving all accessibility issues in an online context for the disabled, especially those that are visually impaired. Contextual differences can alter the experience and outcomes of the use of websites. There is an evident gap in the literature considering accessibility to e-learning for visually impaired students particularly in the context of Sri Lanka. To extend understanding and better inform web designers and other stakeholders, this study addresses the literature gap by identifying the features that need to be improved in e-learning systems for the inclusion of visually impaired students in online learning contexts.

2. Research Objectives and Questions

Research Objectives

1. To identify the accessibility problems related to e-learning systems for Sri Lankan students with visual impairments.
2. To recommend e-learning systems improvement mechanisms for better accessibility for the visually impaired students in Sri Lanka.

Research Questions

1. What accessibility problems in e-learning systems exist for Sri Lankan students with visual impairments specifically?
2. How can e-learning systems be improved for better accessibility for visually impaired students in Sri Lanka?

Research Significance

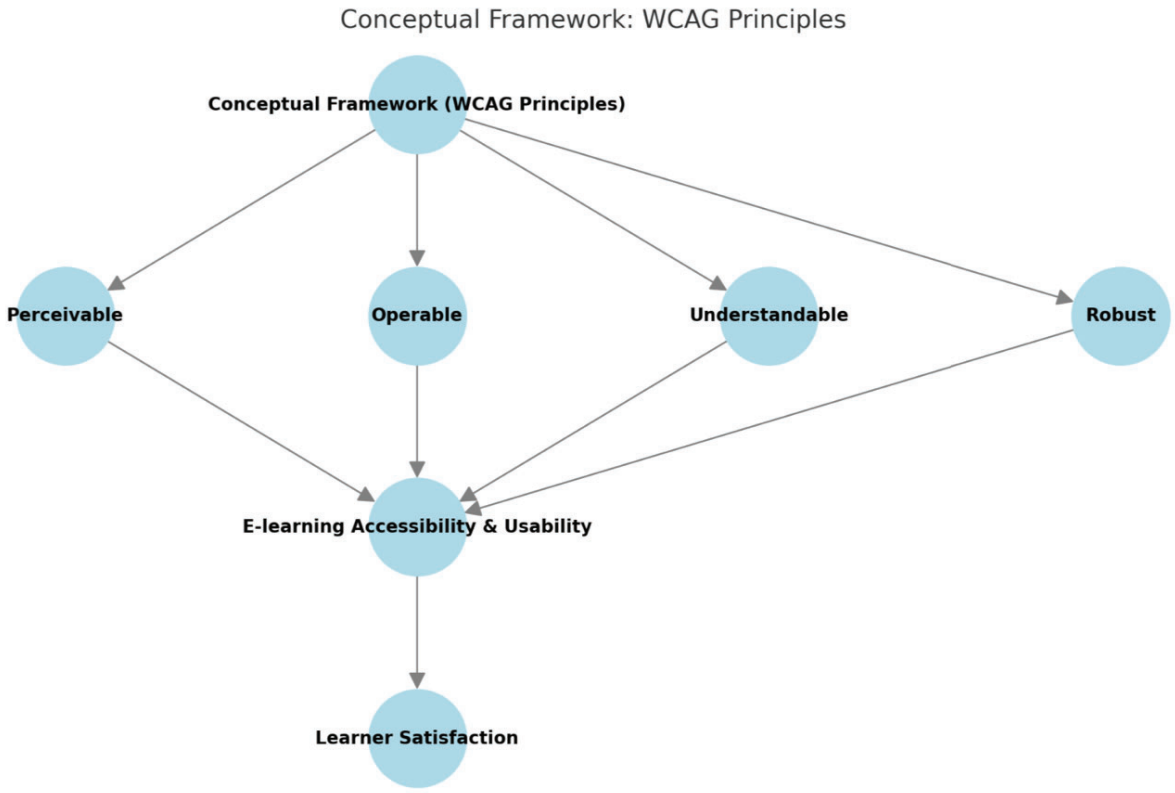
The available literature does not sufficiently examine how visually impaired students interact with e-learning systems, nor the problems typically encountered. In order to design e-learning systems to effectively support visually impaired users, it is important to first identify the design elements that are currently lacking within the e-learning system and how these could be improved for ease of use. The findings of the study will be particularly useful for the Ceylon Deaf and Blind School and the Ministry of Education of Sri Lanka, in ensuring inclusive as well as accessible education. This study will be particularly useful for website designers and developers in obtaining important information related to user experience and design especially related to the education of the visually impaired learner. The findings of this study will also be important to the management of the educational institution on how they could integrate assistive technologies in teaching. Moreover, the study would also contribute to

the body of knowledge on accessibility of e-learning systems for those with disabilities. The study would form a basis for further research in inclusive online learning more specifically in developing countries such as Sri Lanka.

Conceptual Framework

The conceptual framework representing the conceptual framework for your study. Each WCAG principle (Perceivable, Operable, Understandable, Robust) contributes to the accessibility and usability of e-learning systems, which in turn impacts learner satisfaction.

Fig. 1: Conceptual Framework: WCAG Principles



Hypotheses of the Study

The study is guided by the following hypotheses, developed based on the conceptual framework and literature review:

Hypotheses 1

H01: The perceivable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired.

H11: The perceivable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired .

Hypotheses 2

H02: The understandable perceivable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired.

H12: The understandable perceivable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired students.

Hypotheses 3

H03: The operable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired.

H13: The operable factor of the e-learning system has a significant impact on learner satisfaction of visually impaired.

Hypotheses 4

H04: The robust factor of the e-learning system has a significant impact on learner satisfaction of visually impaired

H14: The robust factor of the e-learning system has a significant impact on learner satisfaction of visually impaired

3. Literature Review

Rapid advances in technology have created new possibilities in education, including e-learning, which provides flexible and accessible learning for students of all ages and backgrounds. However, not everyone, especially visually impaired students, has access to these tools. Accessibility to e-learning is an important issue to be addressed in Sri Lanka, where the prevalence of blindness is high. This literature review will review current research on e-learning access for students with visual impairments, focusing on the situation in Sri Lanka. The problems faced by visually impaired students in accessing e-learning and the strategies to solve these problems will be examined. Additionally, the review will identify gaps in the current literature and suggest future research directions. Overall, the purpose of this literature review is to provide insights and recommendations to assist educators and policymakers in improving the accessibility of e-learning for visually impaired students in Sri Lanka and other students who may face similar challenges.

This chapter sets the theoretical basis for the study. Initially the key definitions for this study are reviewed which includes the conceptualization of visual impairment and e-learning. The challenges encountered by visually impaired students in e-learning contexts is then evaluated by investigating prior studies. After which the web accessibility standards and principles are reviewed. Finally empirical evidence related to web-accessibility and implications on visually impaired is reviewed.

According to the World Health Organization (WHO), an impairment is any aberration or loss of anatomical, physiological, or psychological function or structure. This definition encompasses a broad range of conditions. Accordingly, a visual impairment is defined as any chronic visual defect that makes it impossible to carry out everyday duties and that cannot be corrected with standard eyeglasses or contact lenses. In other words, a visual impairment prevents a person from functioning normally in society. According to Holbrook (1996), a visual impairment is a loss of sight that makes it difficult or impossible to carry out everyday duties without the use of specialized tools or assistance. The World Health Organization (WHO) developed the International Statistical Classification of Diseases and Other Health Problems (ICD-10), which categorizes visual impairments into four primary forms: mild impairment, moderate impairment, severe impairment, and blindness. The definition of mild vision impairment states that a person's better eye must have a visual acuity of 6/18 or better. Visual acuity of less than 6/18 but equal to or greater than 6/60 in the better eye is what's considered to be a moderate kind of visual impairment. If a person has a visual acuity of less than 6/60 but greater than

3/60 in their better eye, they are deemed to have severe visual impairment. Visual acuity that is less than 3/60 or concomitant visual field loss in the eye that is considered to be the better eye is what is considered to be blindness.

Visual impairment in a learning environment affects a student's requirement for instructional resources that are not visually focused. This need is taken into consideration while selecting appropriate course materials. In the context of education, "visually impaired" is defined by (Bishop, 2004) as the need for tactual and/or aural channels for learning. This can be developed further, where some visually impaired students have some degree of vision for the sake of movement, while other visually impaired students might build up outlines or faces but find it impossible to read print in any size, and they will be real or auditory learners instead. Children who are visually impaired in their education mostly rely on tactile and auditory input to learn. A visually impaired student needs braille and similar media that can be perceived without the use of vision (Halliday, 2001).

E-learning is described as an alternative means to teaching and learning (Govindasamy, 2002). The basis for e-learning stems from the inclusion of electronic media including internet, extranet, intranet, audio/video tape, interactive video to deliver instructions. It can be viewed as a means of using multimedia, hypermedia and simulation (Maddux, C., 1997). Based on the definition of education and learning wales (ELWA, 2004), e-learning is the use of electronic technology to enhance, deliver and support learning and teaching. E-learning has the ability to transform learning and is effective through various modes including learning in the presence of a lecturer, trainer or teacher, whose delivery is enhanced and supported by electronic materials and media. It also enables the learner to directly interact with the teacher or mentor remotely through electronic media such as videoconferencing. Additionally, learners can learn independent through electronic means with access to online support. Peer assistance has the potential to underlie the learning process in all circumstances, which will rely increasingly on electronic technology the more physically distant the learner is. E-learning, also known as electronic learning or online learning, is the process of acquiring information using electronic technology and media. E-learning is defined simply as "learning that is facilitated electronically."

One of the main senses required for effective learning and development is vision (Cooper, M., Sloan, D., Kelly, B. and Lewthwaite, S., 2010). Access to information is one of the significant issues with low eyesight, and adopting to new technology simply makes exacerbates this issue (Permvattana, 2013). The visually impaired students experience challenges in their daily life, and in their studies, which requires them to frequently use assistive technologies and tools (Creed, 2016).

The difficulties that visually impaired students face are not the same as those that are often experienced by others. The majority of the time, e-learning platforms are developed for students who do not have any issues with their eyesight. Because these systems are predicated on the utilization of visual pictures and interactive activities, it might be challenging for those who have severe visual impairments to use them. They must therefore rely on applications that enables the conversion of screen content and information into more accessible formats (Permvattana, 2013). Some of the challenges that are commonly experienced by the visually impaired are the unavailability of learning materials and special learning or assistance required by these students, (Kesic, 2010) pointed some of the main barriers experienced by visually impaired students as follows: small fonts, evaluation in traditional forms is difficult or impossible, unable to hear lecturer due to lack of clarity in sounds and unable to see clearly what is in the presentation or blackboard. Whilst e-learning may be able to address some of these issues through enlargement of content, adjusting volume or using text to audio applications. Some e-learning systems may still lack these features making accessibility a challenge for visually impaired students. Hence, ensuring website accessibility is imperative in these scenarios.

Web accessibility refers to website development in a way that all users can access it including those with disabilities (Power, 2012). This suggests that any user should have the ability to navigate, perceive, comprehend, interact and contribute in the site without any accessibility challenges to content that is multimedia, text, video, audio, images (Goette, 2007). To address accessibility challenges, accessibility guidelines emerged. The accessibility guidelines is a set of technical requirements that need to be adhered in to ensure the accessibility of digital content for varied users. These guidelines set out the requirements to eliminate barriers to access that may delimit users from perceiving, accessing, interacting or using the website. The Web Content Accessibility Guidelines (WCAG) established the World Wide Web Consortium (W3C) is the most recognized web accessibility standards adhered to globally (Cooper, 2008). Up to now there have been three releases of the WCAG which includes WCAG 1.0 in 1999, WCAG 2.0 in 2008 and WCAG 2.1 in 2018. Every time a new version of WCAG is released, more features, technical standards, technological platforms, and target demographics are covered. The reason for this is that both technology and content are constantly evolving. At present, the valid standard is WCAG 2.0 and WCAG 2.1. Both standards provide accessibility specifications through a set of regulations centered on four core principles: perceivable, operable, understandable, and robust (POUR) (Caldwell, 2008). There are three conformance levels in the guidelines, Level A being the lowest, Level AA being intermediate and Level AAA being the highest. As it reflects the fundamental and minimum accessibility standards that developers should try to conform to, Level A is the easiest to accomplish and complete. In comparison, Level AAA is the most challenging to earn since it has more stringent standards, some of which might be challenging to meet. A website should conform to at least WCAG 2.0 level AA to ensure accessibility for majority of users with disabilities (Power, 2012). 2.5 Web Accessibility Features for Visually Impaired: POUR Principles of WCAG According to the POUR principles, web content should ideally meet the following criteria: (1) it should be completely perceivable by using different senses and ways that users opt for (perceivable), (2) it should be easy to operate with varying user interaction modalities (operable), (3) it should be easy to understand for the widest possible audience (understandable), and (4) it should be robust for use with various platforms along with various assistive technologies (Robust). These fundamentals will be discussed in further depth below

Perceivable refers to the ability for an individual to understand using their senses such as hearing and sight. This means that no information or functionality may be obscured from view or unavailable to a person's other senses. Perceivability is determined through the provision of suitable replacement text, provision of subtitles, provision of clear instructions, perception of content irrelevant to color, etc. Users should be able to hear, see or feel about the information provided. In the case of visually impaired students, if the content cannot be seen, the user must be able to hear or feel it for instance through a connected braille display or text to speech (Evett, 2005). Regardless of the method of access, all content must be readable and perceivable by users (keyboard, mouse, screen reader, etc.). Every text and text function should have a non-text equivalent. For example, alternatives of text for images and captions on videos, color contrast measures such not using red text against green backgrounds (Hyun, 2008). To address this gap, it is important to raise focus approximately the significance of e-learning platform accessibility and the precise wishes of visually impaired college students within the Sri Lankan context. this may involve providing schooling and sources for e-studying developers and educators on how to design and supply available content, in addition to advocating for accelerated availability and accessibility of assistive technologies and sources for visually impaired students.

Operable means that users should be able to easily operate the user interface of the website. The content of the website should be not presented in a form that is difficult for users to operate. Operable factor of a website can be determined through guaranteed use of keyboard, controlled response-time, focused movement, providing stop-function, restrictions of sparkling and flickering (to avoid

seizures), provision of titles by page, repeated region skipping and appropriate text links (Gibson, 2007). Ideally buttons should function irrespective of whether an individual is using a joystick, touchscreen, mouse, keyboard or any other input medium.

The University of Colombo has implemented a screen reader software called NVDA (Non-Visual Desktop Access) that allows visually impaired students to access e-learning content (NVDA, 2011). One major gap is that a website should be functionally usable irrespective of how it is evaluated and users should be able to navigate the content easily (Shrepp, 2006). The website should provide sufficient time for users to react to the presented information, even if their impairments can slow their response.

Understandable refers to the user's ability to easily conceive the content presented on the user interface of a website. Information must be easy to grasp, as well as how the user interface works. This implies that users must be able to comprehend both the material and how the user interface works (the content or operation cannot be beyond their understanding). The understandable factor of a website can be determine through expression of basic language, executing based on user requirement, configuration of tables, provision of labels and content linearization (Albusays, 2016). Content should not difficult or complex for the user to decipher and draw inferences from.

Robust as part of the WCAG principles, is also expressed as progressiveness of technology. This indicates that regardless of what technology may be created in the present or the future, people should be able to access the contents provided by an existing site using it. In other words, consumers should be able to view website content regardless of their browser or device (Baker, 2019). For this, markup language grammar and web application accessibility must be followed in web contents.

The information should work with a range of assistive and non-assistive technologies and continue to work as technology advances. For instance, a video should function no matter the browser or platform an individual is using to view it. Another illustration is the fact that many websites are just inoperable on smartphones, thus mobile viewing should also be accounted for. Content needs to be reliable enough to be understood by a wide range of user agents, including assistive technology (Stefik, 2011).

Rarely are studies available that examine how adhering to online accessibility standards affects user experience. Eleven blind individuals were invited to engage with a variety of websites that varied in their degree of standard compliance by (Aizpurua, 2015). They came to the conclusion that consumers' real perceptions of online accessibility do not always match compliance, and that elements like preconceptions, recollections, expectations, and trust in a website play a significant influence. In addition, the researchers look at how assessments of pragmatic and hedonic characteristics link with perceptions of web accessibility (Aizpurua, 2015) and they suggested using those metrics as a proxy to gauge compliance with web accessibility requirements. Results have revealed that users with visual impairments have a beneficial impact on the scales for affect, the user experience and aesthetic (Schmutz, 2017) as well as on mood (Pascual, 2014). Regarding usability-related outcomes, research methods that included non-disabled subjects have demonstrated that this influence on experience is not just beneficial to users with disabilities but also to users without impairments (Schmutz, 2017). Overall, the majority of recent research have shown a favorable impact of adherence to online accessibility standards on user experience-related metrics.

4. Methodology

Study Design

This chapter is concerned with making philosophical decisions that guide the data collection. In this chapter, the many philosophical considerations that should be taken into account before beginning the process of data gathering and analysis are discussed. This chapter details the procedures that must be followed in order to carry out a scientific investigation.

Research_Philosophy

Research philosophy elaborates on the development of knowledge and guiding ideologies. The study is founded on positivist philosophy, which holds that reality can be viewed via an objective lens, and is hence acceptable for scientific investigation. This viewpoint conforms to observation- and measurement-based scientific knowledge (Bryman, 2007). It asserts that reality is composed of observable, separate elements from an ontological standpoint. The job of the researcher is confined to the collection of data and its impartial evaluation. Consequently, study findings are often apparent and quantitative.

Research_Approach

The research methodology emphasizes the practice that incorporates the broad assumptions into the data collecting, analysis, and interpretation methods. Positivists advocate a deductive research methodology (Tashakkori, 2010). Beginning with an evaluation of current theories of a particular phenomenon, the researcher next tests the hypotheses derived from these theories to reflect the causal linkages between the identified variables, in order to support empirical evidence and validate these ideas (Bryman, 2007).

Research_Strategy

According to (Creswell, 2016) the nature of the study's aims dictates the research design and approach employed to achieve the objectives and answer the research questions. Consequently, the following study follows a case study research approach and focuses largely on the students at Ceylon Deaf and Blind School. This approach provides a comprehensive analysis of a confined system based on a large quantity of data. This is a cross-sectional research design in which data is collected at a certain period in time across a sample population due to time and resource constraints in study administration.

Data Collection Methods

Choice of Methods Mono-method, mixed-method, and multi-method are the three available options for the study's research design (Saunders, 2009). Accordingly, the following study employs a mono-method, which focuses on a single application approach. In accordance with positivist ideology and logical research methodology, the phenomenon is represented quantitatively using correlation to determine the link between the independent and dependent variables. Consequently, the study employs quantitative techniques.

Instrument

A systematic questionnaire was utilized to collect the primary data. At the Ceylon Deaf and Blind School, visually impaired children were given the questionnaire. It is important to highlight that the questionnaire was read aloud to elicit replies. The questionnaire had closed-ended questions,

and its organized design facilitated administration, standardization, and retrieval of quantitative data (Kothari, 2004).

Additionally, while the oral administration of the questionnaire was necessary due to the participants' visual impairments, it introduces potential limitations. These include interviewer bias, variations in tone or emphasis that could influence responses, and reduced privacy, which may affect the authenticity of participants' answers. These limitations should be considered when interpreting the findings. Information such as the age range, gender distribution, educational levels, and the number of participants should be clearly outlined.

Data Analysis Techniques

Data Analysis

The study supports quantitative approaches, which need quantitative analysis in which descriptive statistics are used to describe data in a comprehensible manner. In addition, correlation and regression analyses were employed to establish the significance of the link between the independent and dependent variables.

Reliability and Validity

When the data-gathering instrument measures what it is intended to measure, it is considered legitimate (Kothari, 2004). The supervisor of the study ensured the validity of the research instrument. Reliability is a measure of the consistency of the research's results, and a study is considered trustworthy if its results are consistent when recorded again (Caldwell, 2008). Using the Cronbach Alpha coefficient, the results' dependability is examined.

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While the study employed a quantitative research design, alternative methods such as mixed-methods were considered during the planning phase. However, the decision to proceed with a purely quantitative approach was based on the nature of the research objectives, which focused on measuring the strength and significance of relationships between variables. A mixed-methods approach, while valuable for exploring deeper contextual insights, was not deemed necessary as the research did not require qualitative data for interpretation or theory generation. The quantitative method provided the most efficient and objective way to analyze the structured data collected for this study.

5. Analysis

The importance of technology in modern life is pervasive throughout all sectors, including the educational system. It is impossible to separate information technology from instructional methods and academic advancement. Given how important technology is to our daily lives, it is fundamental for students to acquire problem-solving, organizational, and other essential skills in order to fulfill the demands of a workplace that is becoming more and more technologically oriented and to successfully integrate into society. Thus, the advent of new information and communication technologies has a significant impact on education.

The research was conducted in order to evaluate the e-learning system. The research was conducted under the objectives of identifying the accessibility problems existing for users with visual impairments

and identifying methods for improving the e-learning system for better accessibility. This chapter focuses on analyzing the research data collected during the data collection process. The research was conducted as a quantitative study, and SPSS software was used for analysis. The reliability analysis, regression, and correlation tests were conducted to analyze and test the research variables.

Reliability Test

The reliability test was conducted to ensure and evaluate the accuracy and reliability of the dataset. Cronbach Alpha values were used to assess reliability. According to (Malhotra, 2015), a Cronbach Alpha value greater than 0.7 is considered reliable. The results are shown in the table:

Table 1: Reliability Test

Variable	Cronbach's Alpha
Perceivable	0.833
Understandable Perceivable	0.946
Operable	0.851
Robust	0.760
Learner Satisfaction (Dependent)	0.871

The results indicate that all variables, both independent and dependent, are reliable based on their Cronbach Alpha values exceeding the 0.7 threshold. To provide greater clarity and reproducibility, the structure of the survey instrument should be explicitly stated. The questionnaire consisted of closed-ended questions measured using a Likert scale, typically ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). This type of response scale allows for standardized quantitative analysis and supports the use of Cronbach Alpha to assess internal consistency. Including such details helps contextualize the reliability results and strengthens the methodological transparency of the study.

Correlation Analysis

The correlation analysis was conducted to examine relationships between independent and dependent variables. The results are presented below:

Table 2: Correlation Analysis

Variables	Pearson Correlation	Sig. (2-tailed)
Perceivable → Learner Satisfaction	0.812	0.003
Understandable → Learner Satisfaction	0.897	0.034
Operable → Learner Satisfaction	0.283	0.001
Robust → Learner Satisfaction	0.183	0.004

- **Perceivable**: High correlation (81.2%) and significant (p = 0.003).
- **Understandable Perceivable**: High correlation (89.7%) and significant (p = 0.034).
- **Operable**: Weak correlation (28.3%) but significant (p = 0.001).
- **Robust**: Weak correlation (18.3%) but significant (p = 0.004).

While Perceivable and Understandable dimensions show strong, significant correlations with learner satisfaction, the relatively low correlations for Operable and Robust suggest potential usability and technical concerns. This finding warrants further exploration. It may indicate that users do not find the system sufficiently interactive, navigable, or technically reliable. Follow up qualitative feedback or observational studies could help uncover specific usability challenges or system limitations that affect user engagement. Addressing these issues could enhance overall learner satisfaction and system performance.

Regression Analysis

The regression analysis results are summarized in the tables below:

Table 3: Regression Analysis

Model Summary	**R**	**R Square**	**Adjusted R Square**	**Std. Error**
Model 1	0.803	0.709	0.997	0.07561

ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	7.933	4	2.594	421.459	0.002
Residual	1.184	363	0.004		

Coefficients	**Unstandardized Coefficients**	**t**	**Sig.**
Perceivable	0.758	1.274	0.013
Understandable Perceivable	0.856	-12.041	0.022
Operable	0.226	9.041	0.053
Robust	0.243	13.335	0.061

The regression analysis indicates that Perceivable and Understandable variables have a more significant impact on learner satisfaction, while Operable and Robust factors show relatively lower influence, as reflected in their higher p-values and lower coefficients. This suggests that learners may not view system usability (Operable) or technical strength (Robust) as primary contributors to their overall satisfaction. It is important for the study to explore possible reasons behind this, such as whether learners place more value on content clarity and accessibility over interface interactions or system reliability. These findings highlight a potential gap in the system's usability features that may not align with learner priorities or expectations, which could be explored further through user feedback or qualitative studies.

Summary of Hypotheses Testing

Table 4:Summary of Hypotheses Testing

Hypotheses	Result
H11: Perceivable → Learner Satisfaction	Accepted
H12: Understandable Perceivable → Learner Satisfaction	Accepted
H13: Operable → Learner Satisfaction	Rejected
H14: Robust → Learner Satisfaction	Rejected
Learner Satisfaction (Dependent)	0.871

The rejection of hypotheses H13 and H14 suggests that the Operable and Robust factors have limited or no significant influence on learner satisfaction within this context. This warrants further investigation. For instance, the weak impact of the Operable dimension might indicate that users found interaction elements such as keyboard navigation, responsiveness, or accessibility aids insufficient or unintuitive. Similarly, the lack of impact from the Robust factor could point to possible shortcomings in the underlying technological infrastructure, such as slow loading times, compatibility issues, or limited support for assistive technologies. Exploring these aspects more deeply through user interviews or usability testing could provide valuable insights and guide improvements to better meet learner needs.

6. Conclusion

The importance of technology in modern life is pervasive throughout all sectors, including the educational system. It is impossible to separate information technology from instructional methods and academic advancement. Given how important technology is to our daily lives, it is fundamental for students to acquire problem-solving, organizational, and other essential skills in order to fulfill the demands of a workplace that is becoming more and more technologically oriented and to successfully integrate into society. The aim of conducting this study was to identify ways to improve the accessibility of e-learning systems for the visually impaired students in Sri Lanka. Accordingly, the objectives of the study were to identify the accessibility problems related to e-learning systems for Sri Lankan students with visual impairments and to recommend e-learning system improvement mechanisms for better accessibility for the visually impaired students in Sri Lanka.

Researchers developed the research objectives with the perspective of finding solutions to the existing problems in society, and the hypotheses were developed accordingly. The findings suggest that each user must be able to understand the information presented in an e-learning system. The material should not be overly challenging to learn or comprehend, as it may hinder users from effectively utilizing the system. For instance, forms must be easy to understand and complete, and language must be as comprehensible as possible. Consistency in labeling and interactive elements is also essential. For example, the same term should be used for similar functions across the platform, such as using “buy” instead of “add to cart” in different sections. The language programmed into the

website and the one visibly displayed should align to ensure that screen readers interpret it correctly. Ensuring that these elements are addressed can enhance the usability of e-learning platforms for visually impaired students.

When testing the hypothesis regarding the perceivable factor of e-learning systems, the study found a significant positive relationship between the perceivable factor and learner satisfaction of visually impaired students, with a coefficient of 0.758 and a p-value of 0.013. This demonstrates that the perceivable factor has a substantial impact on user satisfaction. Perceivability implies that no information or functionality can be hidden or unavailable to a person's other senses. Content must be accessible through alternative means, such as being audible or tactile, ensuring that all users can engage with the material regardless of their method of access. Examples include providing alternative text for images and captions for videos. This aligns with the need for inclusive practices, such as avoiding color combinations that are challenging for colorblind users and ensuring content is compatible with Braille displays.

The understandable factor also showed a significant positive relationship with learner satisfaction, with a coefficient of 0.856 and a p-value of 0.022. Understandability emphasizes that the system's content and operation must be clear and comprehensible. This ensures that learners can navigate and engage with the system effectively, fostering better learning outcomes. The findings support the notion that e-learning systems must use accessible fonts, logical formatting, and comprehensible instructions to improve user experience.

The operable and robust factors, however, showed weaker correlations with learner satisfaction. Although these factors are important, the results indicate that their current implementation in the analyzed systems does not significantly impact learner satisfaction. This highlights areas for further improvement, such as ensuring keyboard navigation, providing sufficient time for users to interact with content, and enhancing compatibility with assistive technologies like screen readers.

The study highlights the need to address these issues to improve the accessibility of e-learning systems for visually impaired students. Recommendations include implementing WCAG accessibility practices, such as alternative text, keyboard navigation, and descriptive links, to enhance usability. Additional measures, such as labeling forms correctly, providing text equivalents for multimedia content, and ensuring sufficient color contrast, can further improve accessibility. Training programs for educators and developers can build awareness of accessibility standards, and policy advocacy can drive compliance with these standards. Integrating assistive technologies into e-learning platforms is crucial to ensure that students with visual impairments have equal access to education.

The findings of this study will be especially valuable for the Sri Lankan Ministry of Education and the Ceylon Deaf and Blind School in promoting inclusive education. They also provide critical insights for website developers and designers, helping them create more accessible systems. This study contributes to the understanding of accessibility in e-learning and provides a foundation for further research in inclusive online learning, particularly in developing countries like Sri Lanka. It emphasizes that perceivable and understandable factors are crucial and should be prioritized to ensure that e-learning systems effectively support visually impaired users.

7. References

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