CONTENT ACCESSIBILITY EVALUATION ON A LEARNING MANAGEMENT SYSTEM FOR STUDENTS WITH VISUAL IMPAIRMENTS

PIYARAT THAMMACHOKMONGKOL

MASTER OF SCIENCE

IN

INFORMATION TECHNOLOGY

SCHOOL OF APPLIED DIGITAL TECHNOLOGY

MAE FAH LUANG UNIVERSITY

2025

CONTENT ACCESSIBILITY EVALUATION ON A LEARNING MANAGEMENT SYSTEM FOR STUDENTS WITH VISUAL IMPAIRMENTS

PIYARAT THAMMACHOKMONGKOL

THIS THESIS IS A PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
INFORMATION TECHNOLOGY

SCHOOL OF APPLIED DIGITAL TECHNOLOGY
MAE FAH LUANG UNIVERSITY
2025

THESIS APPROVAL

MAE FAH LUANG UNIVERSITY

FOR

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY

Thesis Title: Content Accessibility Evaluation on a Learning Management System for Students with Visual Impairments

Author: Piyarat Thammachokmongkol

Examination Committee:

Assistant Professor Teerawat Kamnardsiri, Ph. D.	Chairperson
Assistant Professor Worasak Rueangsirarak, Ph. D.	Member
Assistant Professor Surapong Uttama, Ph. D.	Member
Assistant Professor Santichai Wicha, Ph. D.	Member

Advisor:

.....Advisor

(Assistant Professor Worasak Rueangsirarak, Ph. D.)

Dean:

.....

(Associate Professor Nacha Chondamrongkul, Ph. D.)

ACKNOWLEDGEMENTS

First and foremost, I wish to express my deepest gratitude to Mae Fah Luang University for granting me a scholarship that afforded me the invaluable opportunity to pursue a master's degree in Information Technology. Without such financial support for tuition fees, I might not have been able to continue my studies, nor to apply the knowledge I have acquired toward enhancing the effectiveness of my professional endeavors and elevating the quality of my work.

I am profoundly indebted to Assistant Professor Dr. Worasak Rueangsirarak, my advisor, for his invaluable guidance, constructive suggestions, and unwavering support throughout the course of this research. His academic rigor, intellectual depth, and constant encouragement have been instrumental in shaping the direction and enriching the quality of this thesis. I am especially grateful for his continuous inspiration and for the confidence he has placed in my potential, which has served as both a vital source of motivation and a sustaining strength throughout my graduate studies.

My sincere appreciation is also extended to the faculty members and staff of the School of Applied Digital Technology, Mae Fah Luang University, for fostering an academic environment conducive to learning and growth, which has been essential to the successful completion of this research.

Finally, I would like to express my sincere appreciation to Mae Fah Luang University for providing the research funding that made this study possible. I wish to convey my heartfelt thanks to my beloved family, whose unwavering love, patience, and encouragement have supported me unfailingly throughout this academic journey. I am equally grateful to my friends and colleagues for their support, understanding, and treasured companionship, all of which have imbued this scholarly pursuit with meaning, warmth, and cherished memories.

Piyarat Thammachokmongkol

Thesis Title	Content Accessibility Evaluation on a Learning Management System for Students with Visual Impairments
Author	Piyarat Thammachokmongkol
Degree	Master of Science (Information Technology)
Advisor	Assistant Professor Worasak Rueangsirarak, Ph. D.

ABSTRACT

This study validated the use of Web Content Accessibility Guidelines (WCAG) 2.1 to evaluate online content accessibility across three platforms: the University's Official Website, the University-LMS, and the Foundation for Children with Disabilities' e-Learning system. This paper adopted the Level A and AA standards to ensure access for visually impaired students. Evaluation methods combined automated tools WAVE) with manual checks of key pages, including Homepage, Course, Assignment, and Examination functions.

Findings showed that the University-LMS posed the most accessibility challenges, notably missing alternative text, weak keyboard navigation, and low colour contrast. In contrast, the University's Official Website nearly met all AA standards and served as a reliable benchmark. An online survey was conducted with 18 participants (four lecturers, two teaching assistants, and twelve visually impaired students) to confirm the evaluation results and gather feedback based on real-world usage.

Survey responses reinforced experimental findings, highlighting LMS issues such as unclear navigation, missing form labels, and insufficient link descriptions. These barriers created greater difficulties for visually impaired users than the University's Website, which was more compliant with WCAG standards. Although limited in scope, the study underscores the pressing need to improve LMS accessibility. It suggests expanding future research to include a broader range of users, higher WCAG levels, and more inclusive design guidelines.

Keywords: Web Content Accessibility Guidelines, Accessibility Evaluation, Learning Management System, Visually Impaired Students, Inclusive Design

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of the Research Problem

The Thai government has increasingly acknowledged the critical importance of education for individuals with disabilities and has implemented various initiatives to enhance their educational opportunities nationwide. According to the Report on the Situation of Persons with Disabilities in Thailand by the Department of Empowerment of Persons with Disabilities, Ministry of Social Development and Human Security (as of March 31, 2020), Thailand had a total of 2,076,313 registered persons with disabilities. Of this population, 1,083,556 (52.21%) were male and 992,757 (47.79%) were female. Regionally, the highest concentration of persons with disabilities resided in the Northeastern region (829,170 persons, 40.3%), followed by the Northern region (456,966 persons, 22.2%), the Central region (431,683 persons, 20.82%), the Southern region (255,312 persons, 12.30%), and Bangkok (96,182 persons, 4.64%).

Persons with disabilities in Thailand are officially classified into nine categories. The five most prevalent types include: (1) mobility or physical impairments (1,032,455 persons, 49.73%); (2) hearing impairments or communication difficulties (391,785 persons, 18.87%); (3) visual impairments (191,020 persons, 9.20%); (4) mental or behavioral impairments (161,802 persons, 7.79%); and (5) intellectual impairments (141,623 persons, 6.82%).

In terms of educational attainment, approximately 1,517,563 persons with disabilities have received some form of education. However, only about 1,281,173 individuals (61.70%) have completed primary education, while 60,448 persons (2.91%) have not received any formal education. A relatively small proportion, 23,013 persons (1.46%), have attained higher education qualifications.

The accessibility of education for children with disabilities is shaped by multiple interrelated factors, including parental perceptions of disability, societal attitudes, the responsiveness of government officials and educational staff, and the

adequacy of physical infrastructure. Additional barriers include insufficient training for key stakeholders, limited visibility of persons with disabilities within communities, poverty, gender discrimination, inadequate awareness, poor physical accessibility, and the absence of robust support systems and inclusive policy implementation (Sandhya, 2020).

Kumari (2021) highlights that online education offers flexibility in both scheduling and content delivery. Nonetheless, while online learning enables access to downloadable materials, face-to-face instruction remains indispensable, particularly in disciplines such as medicine. The study found that 40% of students reported difficulty understanding online lecture materials, 42.6% encountered challenges in resolving academic queries, and 64.4% believed that face-to-face learning resulted in greater academic achievement.

Burton (2022) identified several challenges associated with online learning among students. These include feelings of isolation, declining motivation, limited access to adequate technological equipment, persistent technical issues, digital distractions, poor time management, and barriers faced by students with disabilities. Online learners often experience social disconnection due to the absence of physical interaction, leading to reduced engagement and academic performance. Motivation tends to diminish over time in the absence of face-to-face interaction, while the high cost of suitable digital devices further exacerbates inequalities among low-income students. Technical difficulties, such as unstable internet connections, also impede learning progress. Moreover, distractions from social media and other online platforms contribute to reduced concentration and productivity. Effective time management emerges as a key skill required for success in online education environments.

Students with disabilities encounter additional barriers in online learning contexts, particularly those with dyslexia, autism spectrum disorder, and sensory impairments. To address these challenges, educators are encouraged to apply the principles of Universal Design for Learning (UDL), which promote inclusivity and accessibility for all learners. Neglecting UDL principles can result in low course completion rates and increased support demands, whereas well-implemented UDL frameworks enhance learning experiences and satisfaction across diverse student populations.

Elda and Ledia (2021) further identified that students face significant challenges in online education, including limited accessibility, lack of motivation, and difficulties in collaborative learning. Lecturers, likewise, require enhanced digital competence to effectively facilitate online instruction. Their findings underscore the necessity for educational policymakers, administrators, and academic staff to strengthen digital infrastructure, pedagogical strategies, and learner support mechanisms. Survey results indicated that 60.2% of students expressed negative attitudes toward online learning, 58.9% believed it did not help them achieve learning objectives, 62.3% reported low motivation, and 65.2% exhibited a lack of enthusiasm.

1.2 Research Objective

1.2.1 To assist visually impaired students in online study.

1.2.2 To evaluate the tools and features of the LMS for identifying the accessibility of visually impaired students by using WCAG 2.1 criteria.

1.2.3 To propose an e-learning structure for visual impairment students in MFU LMS system.

1.3 The Importance of Research

The importance of this research lies in its contribution to the development of equitable and inclusive online learning environments for students with visual impairments in higher education. In Thailand, despite national policies promoting educational accessibility, digital learning platforms often fail to support learners with disabilities fully. Learning Management Systems (LMS), which have become a central component of higher education, are designed primarily for sighted users and therefore pose several usability and accessibility barriers for visually impaired students. These barriers—such as the absence of alternative text, poor keyboard navigation, and inadequate color contrast—hinder independent study and limit equal participation. By evaluating these systems through the framework of the Web Content Accessibility Guidelines (WCAG) 2.1, this research provides a structured and standardized approach

to assess accessibility levels and identify critical gaps that affect the digital learning experience of visually impaired users. Such an evaluation not only highlights existing deficiencies but also raises awareness among academic institutions about the need to adopt accessible web design practices.

Furthermore, this study is significant because it bridges the gap between technical standards and practical implementation within Thai higher education institutions. While WCAG 2.1 has been internationally recognized as the benchmark for digital accessibility, its application within academic LMS platforms in Thailand remains limited and under-researched. The findings of this study will serve as empirical evidence for university administrators, system developers, and policymakers to implement more inclusive digital environments that comply with international accessibility standards. The research also provides a foundation for future development of accessible e-learning frameworks that accommodate diverse learning needs, ensuring that digital transformation in education is aligned with the principles of inclusivity and universal access. By contributing to both academic literature and practical design improvement, this study supports the global agenda of education for all, in line with the United Nations Sustainable Development Goal 4 (Quality Education).

1.4 Research Question

The central research question guiding this study is:

"To what extent does the Learning Management System (LMS) of Mae Fah Luang University (MFU) comply with the Web Content Accessibility Guidelines (WCAG) 2.1 in supporting visually impaired students?"

This question aims to determine the degree of accessibility and usability of MFU's LMS for learners with visual impairments by examining its compliance with WCAG 2.1 at Levels A and AA. The study seeks to identify which specific accessibility criteria are met, partially met, or violated within the LMS and to understand how these affect the user experience of visually impaired students who rely on assistive technologies such as screen readers (e.g., JAWS and NVDA). Additionally, it explores whether the current system design enables equal learning opportunities and independent

engagement in academic tasks such as accessing courses, submitting assignments, and completing online examinations.

To address this main research question, the study also considers several sub-questions:

1. What accessibility barriers do visually impaired students encounter when using MFU's LMS and other online learning platforms?
2. Which aspects of WCAG 2.1 are most frequently overlooked or violated within these systems?
3. How do users—both lecturers and visually impaired students—perceive the accessibility and usability of the LMS in practice?
4. What recommendations can be proposed to improve LMS accessibility and align it more closely with WCAG 2.1 standards?

Together, these questions guide the study toward a systematic evaluation of online learning accessibility and support the formulation of design and policy recommendations for inclusive education in digital environments.

1.5 Scopes of Research

This research focuses on evaluating the accessibility of online learning platforms, particularly the Learning Management System (LMS) used at Mae Fah Luang University (MFU), through the application of the Web Content Accessibility Guidelines (WCAG) 2.1 at Levels A and AA. The study is limited to the assessment of online content accessibility for students with visual impairments, as this group represents one of the most disadvantaged populations in digital education. The evaluation covers selected web pages and functionalities that visually impaired students frequently use during their academic activities, such as the homepage, course page, assignment submission page, and examination page. Both automated evaluation tools, specifically the Web Accessibility Evaluation Tool (WAVE), and manual inspection are utilized to ensure comprehensive assessment and validation of accessibility issues.

The study's scope is delimited to three main platforms: (1) the university's official website, which serves as the benchmark for accessibility validation; (2) the

MFU-LMS, which is the primary subject of evaluation; and (3) the Foundation for Children with Disabilities' e-learning system, which is used as a comparative model. This research does not include a technical redesign or programming modification of the evaluated platforms; rather, it focuses on assessing the degree of compliance and identifying key problem areas according to WCAG 2.1 standards. Additionally, the study incorporates feedback from actual users—lecturers, teaching assistants, and visually impaired students—to verify the practical impact of accessibility barriers identified during the evaluation. The findings are intended to inform future system improvements and accessibility policy development but do not extend to a full-scale implementation of remedial solutions.

1.6 Expected Result

The expected outcome of this research is to produce a comprehensive assessment of online content accessibility in the Learning Management System (LMS) used by Mae Fah Luang University (MFU), based on the standards of the Web Content Accessibility Guidelines (WCAG) 2.1. It is anticipated that the results will reveal both the strengths and weaknesses of the current LMS design in supporting visually impaired students. Specifically, the study expects to identify key accessibility barriers such as the lack of alternative text for non-text content, inadequate keyboard navigation, poor color contrast, missing form labels, and limited audio or text descriptions for multimedia content. These findings will provide empirical evidence of how existing LMS interfaces affect visually impaired learners' ability to interact with course materials, complete assessments, and navigate independently within the system.

Furthermore, the research is expected to contribute to the academic and practical domains by offering recommendations for improving digital accessibility in higher education. The results will serve as a reference framework for other educational institutions aiming to enhance the inclusiveness of their online learning environments. By mapping the degree of WCAG compliance and correlating it with user experience feedback, the study will generate insights into how technical standards can be effectively translated into real-world usability. In addition, the research findings may

guide policymakers, system developers, and educators in designing or updating institutional LMS platforms to align with international accessibility benchmarks. Ultimately, the study is expected to advance the goal of providing equal learning opportunities for all students, regardless of visual ability, and to support the sustainable integration of accessibility principles within Thailand's higher education system.

CHAPTER 2

LITERATURE REVIEW

2.1 Learning Management System (LMS)

A Learning Management System (LMS) is a software application or web-based technology designed to support the planning, implementation, and evaluation of specific learning processes. LMS is widely used in e-learning and typically comprises two main components:

2.1.1 A Server that Performs Core System Functions

1. Storing and managing course materials and user data.
2. Handling authentication and access control.
3. Processing communications between learners, instructors, and administrators.
4. Generating reports on learner progress and system performance.

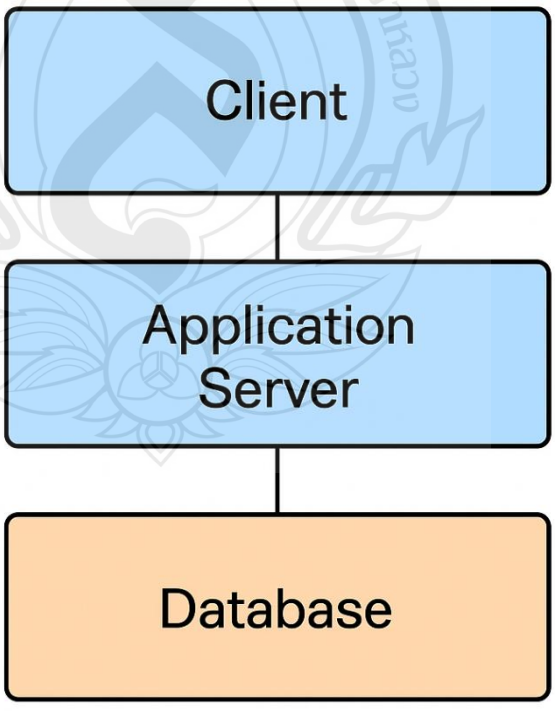


Figure 2.1 An Image of the Server Architecture

2.1.2 A User Interface (UI) Accessed by Instructors, Learners, and Administrators

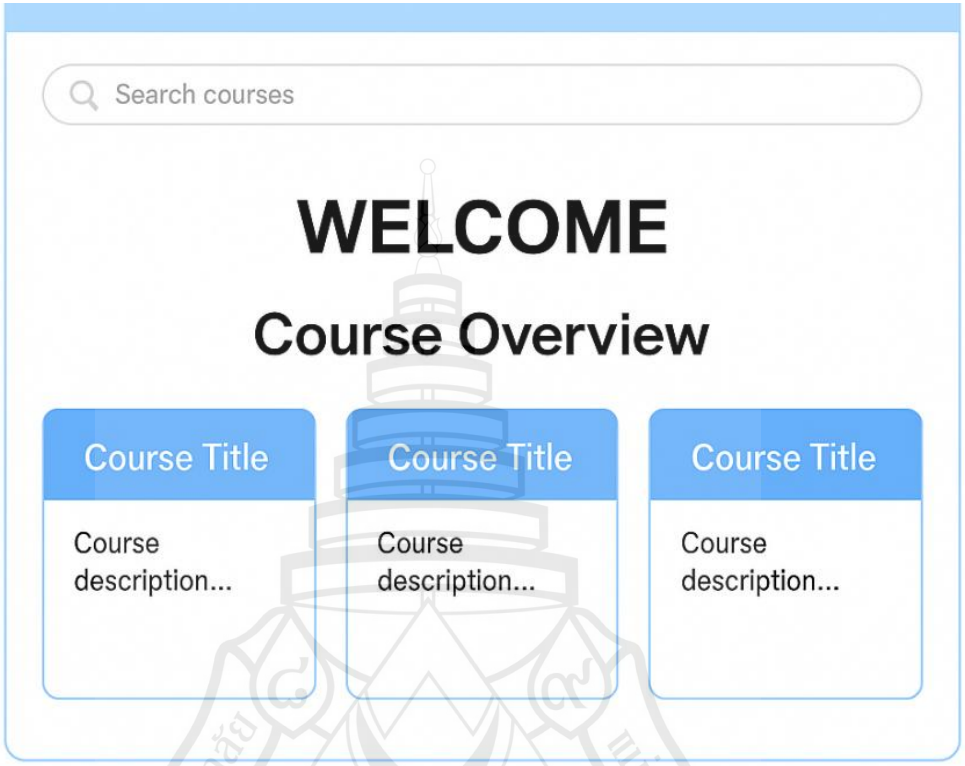


Figure 2.2 A Layout or Template of the LMS Webpage

LMS plays a significant role in enhancing the learning experience within online classrooms. A well-structured LMS fosters an inclusive learning environment by encouraging collaboration, professional training, dialogue, and effective communication among users. Instructors are expected to strike a balance between active learning, use of LMS tools, and adherence to curriculum standards. The system allows instructors to facilitate discussions, organize online activities, establish learning goals, offer choices to learners, and support problem-solving processes. Through their engagement in the LMS, instructors help create an interactive and dynamic learning environment that supports students' independence, motivation, and enthusiasm. Educational stakeholders should refer to evidence-based studies to guide their contributions in LMS design and implementation, especially to support students in learning subjects like mathematics and beyond (Vaughn, 2020).

LMS performs a variety of functions, such as managing, tracking, and reporting on learner-content and learner-instructor interactions. It also supports course registration, monitors student progress, records test results, marks course completions, and allows instructors to evaluate learner performance (Marc, et.al, 2010)

According to Watson (2007), an effective LMS should centralize and automate administrative tasks, offer self-service and self-directed learning options, allow for the rapid development and distribution of content, consolidate training efforts on a scalable web-based platform, support standards and portability, personalize content, and encourage knowledge reuse.

2.1.3 Core Functions of an LMS Include:

2.1.3.1 User profile management

2.1.3.2 Curriculum planning and delivery

2.1.3.3 Assignment tracking and management

2.1.3.4 Discussion board facilitation

2.1.3.5 Access to writing resources

2.1.3.6 Announcements and updates from instructors

2.1.4 Evolution and Role of Learning Management Systems (LMS)

Learning Management Systems (LMS) have emerged as a response to the growing demand for innovative educational solutions, leveraging advancements in information technology and telecommunications. LMS platforms are available in both proprietary and open-source formats, each with distinct cost structures and maintenance approaches. They provide a wide array of functionalities, including course organization, assessment tools, learner progress tracking, communication features, data security protocols, and mobile compatibility. As LMS technology continues to evolve, future iterations are expected to incorporate more personalized learning experiences, enhance online social interactions, and offer deeper analytics to support institutional decision-making (Darren et al., 2020).

Most LMS platforms share core functionalities such as automatic course enrollment, reminders for required training, and administrative options that allow managers to review and approve course content or participation. Integration with human resource systems is also common, enabling institutions to monitor employment eligibility, employee performance goals, and strategic objectives. Additionally, LMS platforms often include controls for access and group assignments based on variables such as geographic location, project involvement, or required security levels (Ellis, 2009).

2.1.5 Historical Development and Definitions of LMS

Historically, terms such as Computer-Based Instruction (CBI), Computer-Assisted Instruction (CAI), and Computer-Assisted Learning (CAL) have been used to describe the integration of computers into education. Today's LMS represent a culmination of these concepts, serving as platforms to manage and deliver educational content while tracking learner engagement and outcomes. Key functions include tracking learner progress, promoting interaction, supporting achievement, managing enrollment, recording grades, and disseminating course updates (Darren et al., 2020).

The evolution of LMS began modestly. The earliest form dates back to 1924, when Sidney Pressey invented a machine that resembled a typewriter and delivered multiple-choice questions. In 1929, M.E. Lazerte introduced the "problem cylinder," followed by the development of an adaptive teaching machine in 1956 that adjusted content based on learner performance. Major advancements occurred in 1970 with the release of HP's personal desktop computer. The advent of the internet in 1982 and the first LMS software by SoftArc in 1990 further accelerated progress. Later, the emergence of Moodle and other open-source platforms revolutionized LMS accessibility and customization. Today, cloud-based LMS platforms offer unprecedented scalability, efficiency, and user engagement (Sooyoung and Jun, 2019).

2.1.6 Administrative Strategies for LMS Implementation

2.1.6.1 LMS integration should be treated as an essential operational requirement within school systems.

2.1.6.2 As Watson and Watson (2007) suggest, effective LMS platforms include features such as user profile management, curriculum mapping, assignment coordination, discussion boards, writing support, and instructor announcements.

2.1.6.3 LMS materials can be accessed in both synchronous (real-time) and asynchronous (on-demand) formats, ensuring flexibility for users.

2.1.7 Conceptual Understanding of LMS

An LMS provides a structured environment conducive to learning, integrating various system functions into a cohesive platform. Users, especially in academic contexts, may encounter specialized terminology and acronyms, making it important to distinguish LMS from other educational technologies with similar attributes.

2.2 Educational System for People with Disabilities in Thailand

2.2.1 Statistics on Education for People with Disabilities in Thailand

According to the Ministry of Social Development and Human Security (March 31, 2020), Thailand had a total of 2,076,313 registered persons with disabilities. Of this number, 1,083,556 were male (52.21%) and 992,757 were female (47.79%). Regionally, the Northeastern region had the largest proportion (40.3%), followed by the Northern (22.2%), Central (21%), Southern (12.4%), and Bangkok (4.1%).

2.2.2 Statistics of People with Disability in Education of Thailand

Disability Types

Among the total population with disabilities: 2,076,313

1. Physical or mobility impairments: 1,032,455 persons (49.7%)
2. Hearing impairments: 391,785 persons (18.9%)
3. Visual impairments: 191,020 persons (9.2%)
4. Mental or behavioral impairments: 161,802 persons (7.8%)
5. Intellectual impairments: 141,623 persons (6.8%)

Educational Attainment of the total population with disabilities:

1. 1,572,343 persons (75.73%) have received some form of education.
2. 60,448 persons (2.91%) have not received any formal education.

Among those educated, the top five educational levels attained are:

1. Primary school: 81.48%
2. Secondary school: 11.24%
3. Bachelor's degree or equivalent: 1.46%
4. The remainder includes vocational diplomas and other forms of non-degree education.

2.2.3 Barriers to Higher Education for Children with Disabilities

Based on a government survey conducted by the Institute of Social Studies and Analysis (2016), the major reasons why children with disabilities are unable to complete higher education include:

1. Family-related factors – lack of understanding or overprotection from family members.
2. Self-doubt – low confidence and fear of academic failure.
3. Social stigmatization – negative attitudes and discrimination from peers or society.
4. Inability to keep up with peers – due to lack of appropriate learning support.
5. Financial difficulties – limited household income and high costs of assistive tools.
6. External factors – inadequate institutional support and insufficient inclusive infrastructure.

2.3 Learning Obstacles in Visual Impaired Students

2.3.1 Learning Obstacles among Visually Impaired Students

The transition from traditional to online learning has introduced both opportunities and challenges, particularly for visually impaired students. According to Kumari (2021), many students reported difficulties in adapting to online education, citing problems related to comprehension, interaction, and engagement. A questionnaire-based study involving 75 participants revealed that 40% of students found the online lecture materials difficult to understand, while 42.6% experienced difficulty in clearing doubts during online sessions. Furthermore, 64.4% of students

believed that they learned more effectively in face-to-face environments compared to online settings.

The findings suggest that while online education offers flexibility and accessibility in terms of time and place, it often lacks the immediacy and personal interaction necessary for effective learning. Technical issues, inconsistent attention levels, and a lack of engagement were identified as major barriers, particularly for students who rely on assistive technologies such as screen readers. Visually impaired learners often face additional cognitive load in navigating non-accessible interfaces, interpreting poorly structured content, or managing limited feedback mechanisms during online lectures. Consequently, these challenges hinder the ability of visually impaired students to fully participate and achieve comparable learning outcomes as their sighted peers.

2.3.2 Comparison between Online and Traditional Learning

Online and traditional learning environments differ significantly in their structure, interaction, and delivery methods. According to Caroline (2020), online education occurs in virtual spaces, allowing learners to study anytime and anywhere, often at a flexible pace. It supports independent learning styles but tends to limit social interaction and collaboration among learners. The primary source of knowledge in online education is digital content such as recorded lectures, documents, and multimedia materials.

In contrast, traditional education takes place in physical classrooms, where learning occurs within fixed schedules and structured settings. Students interact directly with instructors and peers, fostering collaboration and social engagement. The primary source of knowledge is typically the instructor, who provides immediate feedback and guidance. This face-to-face environment encourages active participation and collective learning but may lack the flexibility that online education provides. Therefore, while online learning enhances accessibility and self-paced study, traditional education remains superior in promoting interpersonal communication, motivation, and student engagement—factors that are especially beneficial for students with disabilities who require continuous support and structured interaction.

2.3.3 Problems Regarding Online Learning

Megan (2024) found that the problems regarding online learning in students include:

2.3.3.1 Isolation or Feeling of Isolation

Humans naturally seek social interactions, but online learning falls short of replicating physical interaction. While convenient, online learning can lead to feelings of isolation and disconnection from classmates and teachers. Consequently, students may disengage, turning off webcams and losing attentiveness, negatively impacting academic performance and disciplinary habits due to the lack of personalized attention.

2.3.3.2 Motivation or Lack of Motivation

Students are motivated for online classes, but their motivation decreases over time. The lack of face-to-face interaction hinders concentration in online classes. Without physical presence, students lack urgency, leading to procrastination and declining grades. Contrary to belief, lengthy texts and assignments do not boost motivation and can decrease interest in attending classes.

2.3.3.3 Equipment or Lack of Technical Equipment

Students need a device with a strong internet connection, like a laptop or tablet with a keyboard, to succeed in online classes. However, these devices can be costly, especially for low-income students.

2.3.3.4 Tech issues or Technical Issues

Millennials and Gen Zs, the younger generations, possess computer and technology skills, but still encounter technical difficulties. Learning with computers involves complex software. On physical campuses, students can seek IT department assistance, while in online classes, they must resolve issues independently. Both students and teachers face challenges, including slow internet and video disruptions, disrupting the learning process.

2.3.3.5 Distractions or Online Distractions

The internet is a valuable tool for learning, but it can also be highly distracting. Students often receive constant notifications from various sources like blogs, videos, and social media platforms, diverting their attention from their classes and assignments. Once they become distracted, it's easy for them to mindlessly scroll

through these platforms, ultimately forgetting about their academic responsibilities such as attending classes, completing assignments, and preparing for quizzes or exams.

2.3.3.6 Time Management or Bad Time Management

Balancing everyday tasks alongside the responsibilities of being a student is already challenging. Online learning adds additional tasks, making it even harder to manage everything effectively. While online learning provides flexibility for other activities, it necessitates strong time management skills to successfully fulfill obligations and achieve academic success.

2.3.3.7 Barriers to learning or Disabilities and Special Needs

Some students may encounter difficulties with online classes, particularly those with learning disabilities or other special needs. Students with conditions such as dyslexia, autism, visual impairment, hearing impairment, and other disabilities require additional support and attention to thrive academically. This level of assistance is often better facilitated in a physical classroom setting. There are some of solutions to help the teacher design the material to special needs students:

1. Universal Design for Learning (UDL) is essential for course creators, as it ensures inclusion and understanding for all students.
2. Neglecting UDL can result in low course completion rates and increased customer support demands.
3. Implementing UDL principles can lead to positive customer reviews and referrals.
4. Many online learners fail to complete their courses, with a significant percentage never accessing the content.
5. Course creators should consider course organization, content presentation, and accessibility for visually and hearing-impaired students to address low completion rates.

2.4 Web Content Accessibility Tool

2.4.1 Screen Reader

Kearney and Hurst (2021) highlight the lack of formal research literature on screen reader accessibility in web development. Their study investigates the accessibility challenges blind learners and developers face, using findings from an extensive literature review and interviews with blind programmers. The research underscores the importance of promoting accessibility best practices in web education and developing assistive tools for web design and CSS validation. It also suggests future directions, including integrating AI, tactile graphics, and online communities to support accessible web curriculum and development tools.

Jeffrey et al. (2008) introduced Web Anywhere, a browser-based self-voicing tool that allows blind users to navigate the internet from any sound-enabled device, eliminating the need for expensive screen reader software. The system uses prefetching strategies to reduce delay, making it especially practical for mobile users or those with limited financial resources. User studies confirm that blind individuals can successfully complete web-based tasks with this tool, making it a viable option for accessible browsing on shared or public computers.

Screen readers were also used in educational experiments to simulate the challenges encountered by blind individuals. According to Freire (2007), the use of screen readers in student projects enhanced their understanding of web accessibility concepts and deepened their appreciation of accessibility needs.

Sandhya and Sumithra (2011) explored web accessibility for individuals with visual impairments by analyzing how screen readers like JAWS interact with AJAX-based websites. Their research shows that as web applications become more complex, new challenges arise in making content fully accessible to blind users. The study offers recommendations for improving accessibility in Rich Internet Applications (RIAs) for visually impaired individuals.

2.4.2 Job Access with Speech (JAWS)

Job Access with Speech (JAWS) is the most widely used screen reader in the world. Designed for individuals with significant vision loss, JAWS allows users to

interact with computers using speech output and keyboard navigation. Developed by Freedom Scientific (2018), the software supports a wide range of activities, including web browsing, emailing, spreadsheet management, and database access. Freedom Scientific also provides additional assistive tools such as screen magnifiers, braille displays, and notetakers. Notably, many of the developers and support staff are blind themselves, allowing them to design software that directly reflects the real needs of the blind community. The company remains a leader in assistive technology, committed to innovation and inclusion.

2.4.3 Nonvisual Desktop Access (NVDA)

Nonvisual Desktop Access (NVDA) is a free, open-source screen reader for Windows, developed by NV Access. It provides speech and braille feedback, enabling blind users to interact with computers at no additional cost. According to NVDA (2023), the software supports numerous applications including browsers, email programs, chat platforms, and office suites. It features a built-in synthesizer with support for over 80 languages, as well as capabilities for reading font styles, spelling errors, and formatting. NVDA is compatible with refreshable braille displays and can be run from a USB stick without installation. Available in 54 languages, it works with both 32- and 64-bit versions of Windows and is functional on sign-in and secure screens. It also supports standard accessibility APIs and provides auditory cues for system focus and mouse tracking.

2.4.4 PPA Tatip Program

The PPA Tatip Program is a Thai-language text-to-speech software that works in conjunction with screen readers such as JAWS and NVDA. Developed by the Thailand Association of the Blind, it cannot function independently and is intended to complement screen reader functionality for Thai users. Its effectiveness is supported by the linguistic similarities between Thai and the structure of these screen readers, enhancing access for visually impaired users in Thailand (Thailand Association of the Blind.)

2.5 IT Audit: Information Technology Auditing

IT auditing is a systematic process used to evaluate the integrity, efficiency, and security of IT systems, infrastructures, and organizational policies. It aims to ensure compliance with regulations and standards, support data governance, and protect critical digital assets. According to Asniarti and Iskandar (2019), IT governance audits should assess whether IT strategies align with broader organizational goals and evaluate the performance and added value of IT resources. The audit scope must include activities related to planning, management, and monitoring of IT processes. Effective IT audits require a skilled audit team with the necessary expertise to carry out comprehensive evaluations.

2.6 Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) 2.1 present a set of international standards aimed at improving the accessibility of web content for individuals with diverse disabilities, including visual, auditory, physical, speech, cognitive, language, learning, and neurological impairments. While it may not cover every possible combination or severity of disabilities, WCAG 2.1 is designed to support the widest feasible audience. These guidelines apply across various digital platforms—desktops, laptops, tablets, and mobile devices—and enhance usability for all users, including older adults with age-related limitations (W3C, 2018).

The success criteria in WCAG 2.1 are technology-neutral and testable statements, designed to allow flexibility in implementation while ensuring measurable results. Supporting documentation is available to help developers interpret the criteria and implement them using specific technologies. For newcomers or those seeking technical guidance, the WCAG Overview offers a centralized entry point for accessing detailed resources, educational materials, and documentation.

WCAG is relevant to a wide range of audiences, such as web developers, content creators, policy makers, educators, and accessibility consultants. To address their diverse needs, WCAG offers multiple layers of guidance, including high-level

principles, detailed guidelines, measurable success criteria, and practical implementation techniques.

Key Layers of WCAG Guidance:

1. Principles: The foundation of WCAG is built upon four essential principles of accessibility:

1) Perceivable – Information and UI components must be presentable in ways that users can perceive.

2) Operable – UI components and navigation must be usable.

3) Understandable – Content must be readable and predictable.

4) Robust – Content must be interpretable by a wide range of user agents, including assistive technologies.

2. Guidelines: Under each principle lie 13 guidelines that define key accessibility goals. These serve as a framework for understanding and implementing accessible content but are not directly testable on their own.

3. Success Criteria: Each guideline includes one or more testable success criteria, which provide the basis for measuring conformance. These are categorized into three levels:

1) Level A – Minimum level of accessibility.

2) Level AA – Deals with the biggest and most common barriers for users.

3) Level AAA – The highest level of accessibility and often the most comprehensive.

4. Techniques:

1) Sufficient Techniques – Practical methods that, if correctly implemented, meet the success criteria.

2) Advisory Techniques – Additional practices that further enhance accessibility, even if they are not required for conformance.

3) WCAG documentation also includes examples of common failures that developers should avoid, often accompanied by explanations and sample code.

By using all applicable layers—including principles, guidelines, testable criteria, and both sufficient and advisory techniques—content authors can create more accessible and user-friendly experiences for a broad and diverse audience. Embracing

WCAG not only ensures compliance with standards but also significantly improves the overall usability, inclusiveness, and effectiveness of digital content.

Table 2.1 Understanding Accessibility: WCAG's 13 Guidelines

Guideline	Level	Description
1.1 Text Alternatives		
1.1.1	A	Every non-text element includes a corresponding text description.
1.2 Time-Based Media		
1.2.1	A	Substitute content is available for all prerecorded audio and video.
1.2.2	A	All prerecorded videos include captions.
1.2.3	A	Audio descriptions or equivalent alternatives are available for every prerecorded video.
1.2.4	AA	Captions are available for all real-time audio content.
1.2.5	AA	All prerecorded videos include audio descriptions.
1.2.6	AAA	Sign language interpretation is available for all prerecorded audio.
1.2.7	AAA	Detailed audio descriptions accompany all prerecorded videos.
1.2.8	AAA	An alternative format is available for all prerecorded time-based media.
1.2.9	AAA	An alternative media format is available for all live video content.
1.3 Adaptable		
1.3.1	A	All content and layout are provided as text or can be identified through programming.
1.3.2	A	The content is arranged in a logical sequence.
1.3.3	A	Comprehending the content's context does not rely on any sensory input.

Table 2.1 (continued)

Guideline	Level	Description
1.3.4	AA	The content can be accessed regardless of the device's orientation.
1.3.5	AA	Each input field has a label and/or descriptive text that clarifies its purpose.
1.4 Distinguishable		
1.4.1	A	Information is communicated by more than just color.
1.4.2	A	Audio lasting longer than 3 seconds includes controls to pause, stop, or adjust volume.
1.4.3	AA	Every text element maintains at least a 4.5:1 contrast ratio.
1.4.4	AA	Text can be enlarged to 200% without losing readability.
1.4.5	AA	Text must be displayed as actual text rather than images, except for logos.
1.4.6	AAA	Every text element maintains at least a 7:1 contrast ratio.
1.4.7	AAA	Audio content must either have no background sound or the background audio should be at least 20 decibels quieter than the main audio.
1.4.8	AAA	Users can personalize how text appears visually.
1.4.9	AAA	Images containing text serve purely decorative purposes.
1.4.10	AA	Content can be viewed without horizontal and vertical scrolling.
1.4.11	AA	Interface elements must have at least a 3:1 contrast ratio.
1.4.12	AA	The text maintains suitable line height and spacing in proportion to the font size.
1.4.13	AA	When content appears on hover, it should be possible to dismiss it, keep it visible while hovering, and ensure it remains persistent.

Table 2.1 (continued)

Guideline	Level	Description
2.1 Keyboard Accessible		
2.1.1	A	All content should be fully accessible using only a keyboard for input.
2.1.2	A	A user should be able to move away from a component using only the keyboard.
2.1.3	AAA	All content can be operated without the need for precise timing of keystrokes.
2.1.4	A	If a keyboard shortcut uses a single character, users should have the ability to customize it.
2.2 Enough Time		
2.2.1	A	Whenever possible, time limits for content should be adjustable or able to be disabled.
2.2.2	A	All time-based media longer than 5 seconds must include controls for play, pause, and stop.
2.2.3	AAA	Timing should not be a critical element of the content or the user experience.
2.2.4	AAA	Users should be able to delay or prevent interruptions.
2.2.5	AAA	When an authenticated session expires, no data is lost once the user logs in again.
2.2.6	AAA	Users receive a warning about any potential data loss if their session authentication expires.

Table 2.1 (continued)

Guideline	Level	Description
2.3 Seizures and Physical Reactions		
2.3.1	A	No content on the page flashes more than three times per second, or the flashing stays below a defined intensity level.
2.3.2	AAA	Nothing on the page flashes more than 3 times per second
2.3.3	AAA	Users can disable animations that start as a result of interactions.
2.4 Navigable		
2.4.1	A	Users can bypass repeated sections that appear across multiple pages of a website.
2.4.2	A	Each page includes a clear and descriptive title.
2.4.3	A	The sequence in which elements receive focus follows a logical and intuitive order.
2.4.4	A	The intent of each link is clear from its text alone, without relying on surrounding content for context.
2.4.5	AA	There are multiple methods available for finding a specific page within the website.
2.4.6	AA	Headings and labels clearly describe their purpose or content.
2.4.7	AA	The current focus on the website is visually clear and easily noticeable.
2.4.8	AAA	Users can easily identify their current location within the website.
2.4.9	AAA	Each link’s purpose is clear from its text alone.
2.4.10	AAA	Content is structured using section headings for better organization.
2.5 Input Modalities		
2.5.1	A	Content can be managed using various types of input methods.

Table 2.1 (continued)

Guideline	Level	Description
2.5.2	A	To avoid accidental pointer input, functions should not trigger on down-events, should complete on up-events, or ensure that up-events undo the actions started by down-events.
2.5.3	A	Visible labels and the programmatic names for the same control should be consistent.
2.5.4	A	Every function controllable by device motion should also have an equivalent component control.
2.5.5	AAA	All pointer input targets must be no smaller than 44 by 44 pixels.
2.5.6	AAA	The website content supports multiple input methods and does not restrict users to only touch screen interactions.
3.1 Readable		
3.1.1	A	The HTML element specifies the page's language programmatically.
3.1.2	AA	Content on the page that uses a different language is marked programmatically.
3.1.3	AAA	Specialized terms or uncommon words are explained.
3.1.4	AAA	Abbreviations and acronyms are identified and defined programmatically.
3.1.5	AAA	Supplementary text is available for material that requires advanced reading skills.
3.1.6	AAA	Pronunciation guidance is provided for words where pronunciation affects the meaning or context.
3.2 Predictable		
3.2.1	A	When a component gains focus, the surrounding content context remains unchanged.

Table 2.1 (continued)

Guideline	Level	Description
3.2.2	A	Modifying a component's settings should not alter the content context unless the user is informed about the change.
3.2.3	AA	Navigation elements that appear on multiple pages remain consistent throughout.
3.2.4	AA	Components with the same function are uniform throughout the website.
3.2.5	AAA	Content context changes occur only when initiated by the user.
3.3 Input Assistance		
3.3.1	A	All input errors are communicated to the user through text.
3.3.2	A	Provide labels or instructions whenever user input is needed.
3.3.3	AA	Offer suggestions for correcting automatically detected errors when the cause is identified.
3.3.4	AA	Any data that can be modified should be reversible, verifiable, or confirmed—especially for legal or financial information.
3.3.5	AAA	Offer extra instructions or details for context-sensitive inputs when the label alone is insufficient.
3.3.6	AAA	Users should be able to undo, review, or verify content they have submitted.
4.1 Compatible		
4.1.1	A	All markup is structured following the specifications of the language.
4.1.2	A	Apply name and role attributes when developing custom components.
4.1.3	AA	Notify users of significant content updates using status messages.

2.7 Web Content Accessibility Evaluation

Evaluating the accessibility of web-based learning environments is essential to ensuring that digital platforms are inclusive and usable by all learners, including those with disabilities. Several studies have explored the methods, challenges, and standards associated with web accessibility evaluation, particularly in the context of WCAG 2.0 and 2.1 compliance. The following five studies are representative of current approaches and findings in this domain.

2.7.1 Freire and Paiva (2021): Integrating Automated and Manual Evaluation Methods

Freire and Paiva conducted a hybrid evaluation of educational websites using both automated tools and manual inspection. The study demonstrated that automated tools, such as WAVE and Axe, were effective in detecting measurable accessibility violations (e.g., missing alt text, color contrast issues), but failed to identify contextual problems like unclear link purposes and inappropriate heading structures. Manual evaluation provided complementary insights into user experience barriers. Their combined approach improved accuracy and established a framework for mixed-method accessibility auditing aligned with WCAG 2.1 Level A and AA.

2.7.2 Al-Khalifa et al. (2020): Accessibility Assessment of University E-Learning Systems

This study evaluated five university Learning Management Systems (LMSs) from the Middle East using WCAG 2.1 criteria. Automated testing was supplemented by task-based usability testing with students who were blind or visually impaired. Results revealed that most LMS platforms partially conformed to Level A but failed several Level AA criteria, especially regarding keyboard navigation, form labeling, and multimedia alternatives. The authors concluded that LMS developers need to integrate accessibility from the design phase rather than relying on post-development compliance checks.

2.7.3 Vigo, Brown, and Conway (2021): Measuring Web Accessibility beyond Compliance

Vigo and colleagues proposed an extended evaluation model that combined WCAG compliance checking with usability metrics such as task completion time and error rate among users with disabilities. Their study highlighted that compliance does not necessarily equate to accessibility, as some WCAG-conformant websites still presented cognitive barriers or poor interaction design. This approach encouraged researchers to move beyond binary "pass/fail" auditing and to adopt human-centered evaluation frameworks that integrate both quantitative and experiential data.

2.7.4 Ahmad and Hashim (2022): Evaluating Accessibility of Higher Education Portals

Ahmad and Hashim examined ten higher education portals in Southeast Asia using WCAG 2.1 automated audits (via WAVE and AChecker) and expert reviews. The analysis revealed recurring issues such as unlabelled form controls, missing ARIA roles, and poor mobile responsiveness. Although most websites achieved partial Level AA compliance, accessibility for visually impaired users remained limited. The authors emphasized the importance of continuous monitoring and institutional accessibility policies to maintain compliance over time, especially during platform updates.

2.7.5 Lee and Chen (2023): Accessibility Evaluation in Learning Management Systems for Inclusive Education

Lee and Chen focused on Moodle-based LMS implementations used by universities across East Asia. Their evaluation followed WCAG 2.1 criteria and involved both technical audits and user testing with screen reader users. The findings indicated that although Moodle itself supports accessibility standards, local implementations often introduced new barriers due to inconsistent customization. The study proposed a four-phase accessibility framework—assessment, remediation, validation, and training—to ensure that LMS deployment remains inclusive for all learners.

2.8 Summary

Across these studies, common challenges emerge in achieving full WCAG 2.1 compliance, including:

1. Inconsistent application of accessibility principles during platform customization
2. Overreliance on automated testing without manual or user-based verification
3. Lack of institutional policies for sustained accessibility improvement
4. Limited awareness among developers regarding assistive technology compatibility

These related works collectively highlight that a mixed-method evaluation strategy—combining automated tools, manual inspection, and user testing—is the most effective way to ensure that educational platforms provide equal access for learners with visual impairments.

CHAPTER 3

METHODOLOGY

3.1 Research Overview

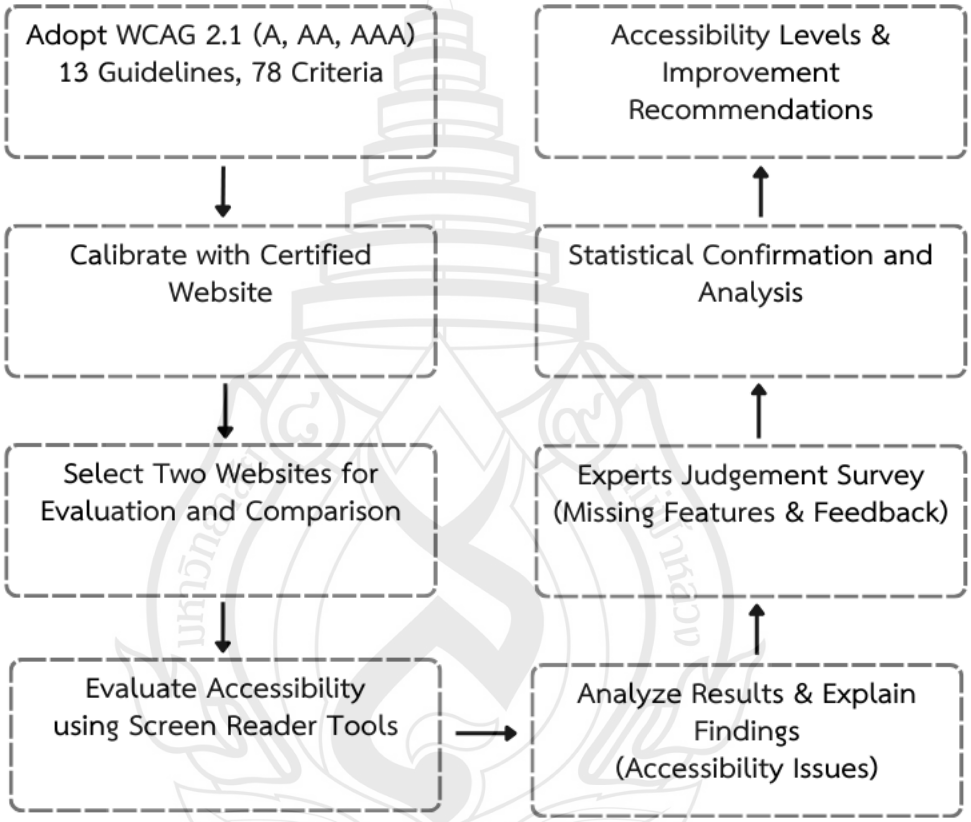


Figure 3.1 Proposed Research Framework

The purpose of this study is to evaluate the accessibility of web-based learning platforms through the application of the Web Content Accessibility Guidelines (WCAG) 2.1, which serve as the international standard for web accessibility. The research primarily focuses on identifying accessibility barriers encountered by visually impaired students when using Learning Management Systems (LMS) in higher education. The study adopts both quantitative and qualitative approaches by combining

automated evaluation tools, manual inspection, and user feedback to ensure a comprehensive understanding of accessibility issues.

The proposed research framework, illustrated in Figure 3.1, outlines the main stages of the study:

1. calibration of WCAG criteria using a certified accessible website,
2. evaluation of university and external LMS platforms,
3. validation of findings through user surveys and interviews, and
4. synthesis of results to propose accessibility improvement guidelines.

The WCAG 2.1 consists of 78 success criteria organized under four guiding principles—Perceivable, Operable, Understandable, and Robust (POUR). These principles form the theoretical foundation of this study. While the WCAG 2.1 provides three levels of conformance—A, AA, and AAA—this research applies Levels A and AA, which are widely regarded as practical and achievable standards for most educational websites. The evaluation focuses on how well selected LMS platforms adhere to these standards in providing accessible online learning environments for visually impaired students.

3.2 Data Collection

This research employs a multi-stage data collection strategy combining both technical auditing and user validation. The goal is to generate both objective and experiential data regarding the accessibility of online content. Two major data sources are used:

1. automated evaluation reports generated by accessibility testing tools, and
2. user responses gathered through structured questionnaires and interviews.

3.2.1 WCAG Standard Calibration

To ensure the validity and reliability of the accessibility evaluation process, a calibration phase was conducted using the official website of Mae Fah Luang University (MFU). This website had been officially recognized by the Office of the National Digital Economy and Society Commission (ONDE) as a Thailand Digital Accessibility Award 2023 recipient. The MFU website, which achieved Level AA

compliance, served as the benchmark for assessing the accuracy of the researchers' application of WCAG 2.1 standards.

During calibration, the research team systematically tested 50 WCAG criteria (Level A + Level AA) across six representative pages: Homepage, News, Announcements, Activity News, About, and Course pages. Both automated evaluation using WAVE and manual checking were applied to detect errors and confirm accessibility compliance. The findings from this step established the baseline for evaluating LMS websites, ensuring the consistency of evaluation metrics throughout the study.

By confirming that the benchmark website met the expected accessibility level, the researchers verified that their methods could accurately detect both compliance and non-compliance issues. This phase also provided an opportunity to refine the data recording templates, ensuring that subsequent audits of LMS platforms followed the same rigorous structure.

3.2.2 Content Accessibility Evaluation on Learning Management Systems

After calibration, the accessibility evaluation extended to two additional LMS platforms:

1. The internal LMS of Mae Fah Luang University (MFU-LMS) – the primary case study,

2. A secondary LMS operated by the Foundation for Children with Disabilities (FCD) – serving as a comparative benchmark.

Each LMS was evaluated across six key functional areas that visually impaired students commonly interact with: Homepage, Course Page, Assignment Submission Page, Exercise Page, and Examination Page. The WAVE tool was employed for automated analysis, while manual inspection verified issues that automated tools could not detect—such as missing captions, link context, heading hierarchy, or ambiguous labels.

The quantitative analysis recorded the number and types of WCAG violations, while the qualitative component assessed the severity and user impact of each issue. The evaluation matrix captured whether each criterion was *passed, failed,* or *partially met*, followed by an explanation of the underlying cause.

This mixed-method approach ensured a holistic assessment: the automated results provided measurable compliance data, whereas manual checks offered contextual insights into usability problems from the perspective of screen reader users.

3.3 Evaluation Method

The evaluation framework combines both quantitative auditing and qualitative validation to measure accessibility effectiveness.

3.3.1 Quantitative Phase

The quantitative evaluation used WCAG 2.1 Levels A and AA as the measurement scale. Each LMS was assessed against 50 key criteria distributed across four WCAG domains:

1. Perceivable (20 criteria) – such as text alternatives, color contrast, captions for multimedia.
2. Operable (17 criteria) – including keyboard access, navigation, and timing controls.
3. Understandable (10 criteria) – such as readable text, predictable navigation.
4. Robust (3 criteria) – compatibility with assistive technologies.

Each criterion was scored as:

1. 1 – Fully compliant
2. 0.5 – Partially compliant
3. 0 – Non-compliant

The total compliance score was calculated to determine the overall accessibility level of each platform. A website achieving 80% or more compliance was considered accessible at Level AA.

3.3.2 Qualitative Phase

To validate the findings, the study employed a survey and interview process with a purposive sample of 18 participants:

1. 4 lecturers who use MFU-LMS to deliver courses
2. 2 teaching assistants responsible for uploading and managing content

3. 12 visually impaired students enrolled in MFU programs

Participants were asked to respond to 10 statements derived from WCAG criteria that were marked as “non-compliant” during the evaluation. Responses were rated on a 5-point Likert scale (Strongly Agree to Strongly Disagree). The survey aimed to confirm whether the identified accessibility problems affected users’ actual experiences.

After completing the questionnaire, semi-structured interviews were conducted with visually impaired students to gain deeper insights into their experiences using screen readers such as JAWS and NVDA. Interview questions explored navigation difficulties, content comprehension, and interaction with multimedia and forms.

3.4 Tools and Instruments

To ensure the reliability and validity of results, the following tools and instruments were employed:

3.4.1 WAVE (Web Accessibility Evaluation Tool):

An automated accessibility checker by WebAIM used to identify errors such as missing alternative text, color contrast issues, and invalid HTML elements.

3.4.2 NVDA (NonVisual Desktop Access):

A free, open-source screen reader used to simulate the experience of visually impaired students navigating LMS platforms.

3.4.3 JAWS (Job Access with Speech):

A commercial screen reader employed to test compatibility with widely used assistive technologies.

3.4.4 Manual Evaluation Checklist:

Developed based on WCAG 2.1 guidelines. It includes human-judgment-based criteria that automated tools cannot detect, such as logical reading order, contextual link descriptions, and heading hierarchy.

3.4.5 Questionnaire and Interview Guide:

Structured instruments designed to collect feedback from users and educators regarding perceived accessibility and usability challenges.

All tools were validated through a pilot test during the calibration phase to ensure consistency across evaluators and websites.

3.5 Data Analysis Procedures

Data analysis involved both descriptive and inferential techniques:

3.5.1 Quantitative Data:

Accessibility compliance percentages were calculated for each WCAG domain and summarized in tables. Comparative analysis between the MFU-LMS and the FCD e-learning system identified recurring violations and platform-specific weaknesses.

3.5.2 Qualitative Data:

Responses from questionnaires were summarized using descriptive statistics (mean, mode, and frequency). Interview transcripts were analyzed using thematic coding, allowing researchers to identify patterns related to navigation difficulties, comprehension barriers, and user satisfaction.

The triangulation of quantitative and qualitative findings ensured comprehensive validation of results, strengthening the credibility of the conclusions.

3.6 Ethical Considerations

Ethical standards were strictly followed throughout the research process. All participants were informed of the study's objectives, procedures, and their rights before participating. Informed consent was obtained from each participant, and anonymity was guaranteed by assigning code numbers instead of personal identifiers.

The study also ensured that participation was voluntary and that participants could withdraw at any stage without consequence. Since visually impaired students are considered a sensitive group, particular attention was paid to accessibility and comfort during interviews—questions were read aloud, and responses were recorded with permission. Data collected were stored securely and used solely for academic purposes.

3.7 Summary of Methodology

This chapter presented the methodological framework adopted for evaluating web accessibility of LMS platforms using WCAG 2.1 standards. The research followed a mixed-method approach, integrating automated and manual evaluations with user-based validation.

The calibration phase established reliability through comparison with a certified accessible website, while subsequent evaluations provided comparative insights between the MFU-LMS and the FCD platform. The combination of technical audits, surveys, and interviews allowed for a nuanced understanding of accessibility barriers affecting visually impaired learners.

By grounding the analysis in WCAG 2.1 and employing both quantitative precision and qualitative depth, this methodology ensures a robust foundation for the findings presented in Chapter 4.

CHAPTER 4

RESULTS

4.1 Summary of Research

This research focused on evaluating the accessibility of Mae Fah Luang University's Learning Management System (LMS) using the Web Content Accessibility Guidelines (WCAG) version 2.1, specifically at the AA conformance level. The goal was to identify issues that may affect the usability of the system for people with disabilities and to propose improvements.

The study followed the methodology outlined in Chapter 3, which involved three key phases: adopting WCAG 2s.1 principles, conducting accessibility evaluation based on 78 criteria, and identifying accessibility barriers to propose better design solutions.

To ensure the evaluation process was reliable, the MFU Official Website was first tested as a baseline. This website generally conformed to Level AA criteria, confirming that the university is capable of building accessible websites. The research then moved on to the LMS, which is the main subject of the study.

Using both automated (WAVE tool) and manual methods, the LMS was evaluated against Level AA criteria. and was distributed to real LMS users to collect feedback and assess their awareness of accessibility issues.

In addition, the Online Learning Website was also reviewed to compare accessibility across related systems. The results helped verify whether the issues found were unique to LMS or part of a broader pattern in the university's digital ecosystem.

Finally, the research emphasized why only Level AA was selected for this evaluation. Level AA represents a balanced, internationally recognized standard for web accessibility in education, while Level AAA is often too strict for practical implementation and may compromise design aesthetics.

The findings from this phase will be used to support the design of more inclusive digital learning environments and to recommend specific changes for improving the LMS interface for all users, especially those with disabilities.

4.2 LMS and Websites Selection

I have selected 3 websites to validate them with WCAG 2.1. The 3 websites we selected are:

4.2.1 Learning Management System, MFU

LMS (Learning Management System) is an online learning system website of Mae Fah Luang University for students and lecturers in the university. It provides the teaching contents and examination functions for the lecturers and provides the learning environment of the student. The pages we selected to check were the Homepage, Course Page, Exercise Page, Assignment Page, and Exam 2 Page. I selected them to cover all the features for basic use for the disabled. The selected pages represent core user interactions that align with the four principles of WCAG 2.1 (Perceivable, Operable, Understandable, and Robust — POUR), which define accessibility requirements for users.

Each page was selected to reflect real user needs, as they are the most accessed parts of an LMS and directly impact students' learning activities. Accessibility in these areas ensures that disabled users can perform the same core tasks as others.

This website is a main LMS to be analyzed in this research. (https://lms.mfu.ac.th/).

1. Homepage

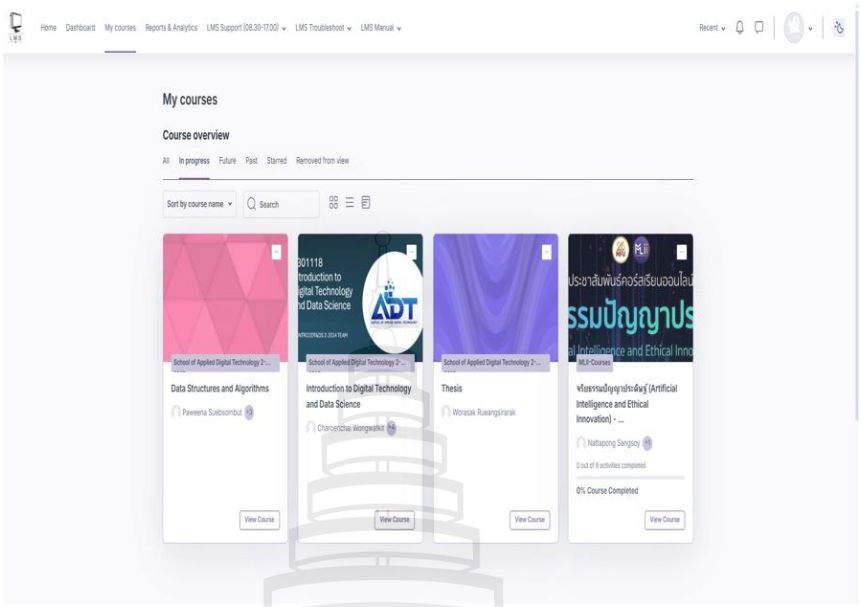


Figure 4.1 LMS Homepage

On the home page, it is used to select courses that are registered in that term. The website consists of the registered courses, has a feature to search for courses, has courses in the future, past, and can select the website page format.

2. Course Page

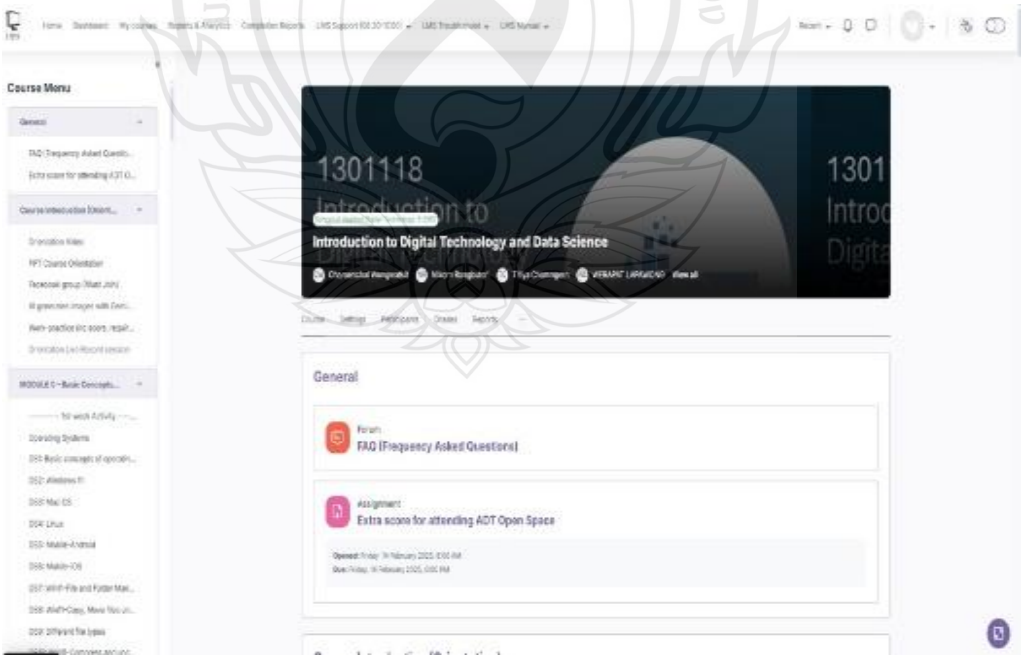


Figure 4.2 LMS Course Page

On the course page, after selecting a course from the homepage, on the course page, the weekly exercises are assigned by the instructor. Details include topics to be studied, chapters, and due dates, etc.

3. Exercise Page

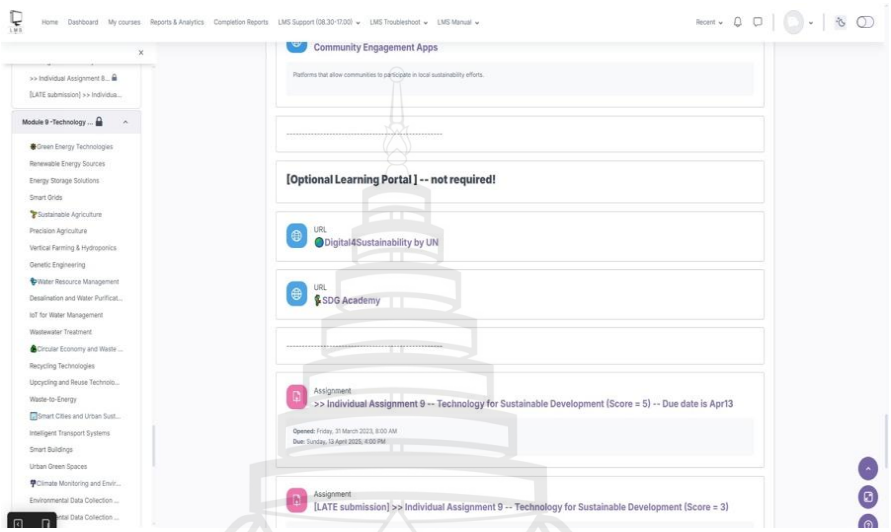


Figure 4.3 LMS Exercise Page

On the Exercise page, after the test from the course page, this page will have details about the exercises in this topic, such as URLs for self-learning, textbooks used for reference in that exercise, video tutorials for doing basic exercises, and assignment submission pages.

4. Assignment Page

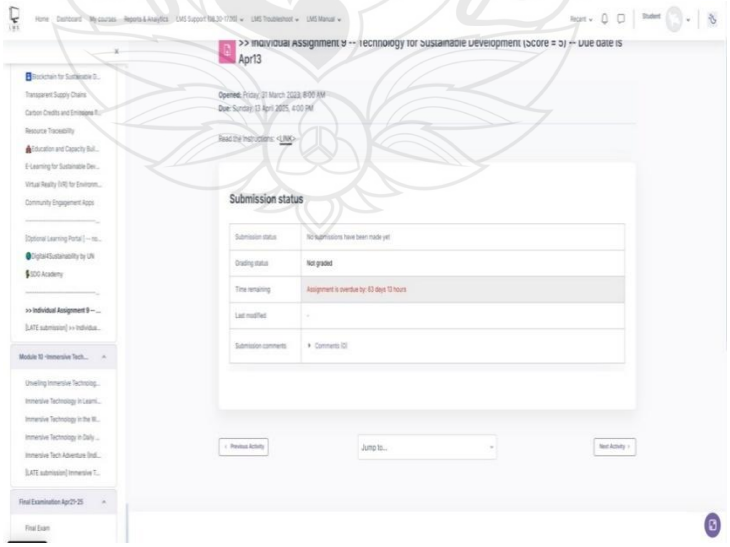


Figure 4.4 LMS Assignment Submission

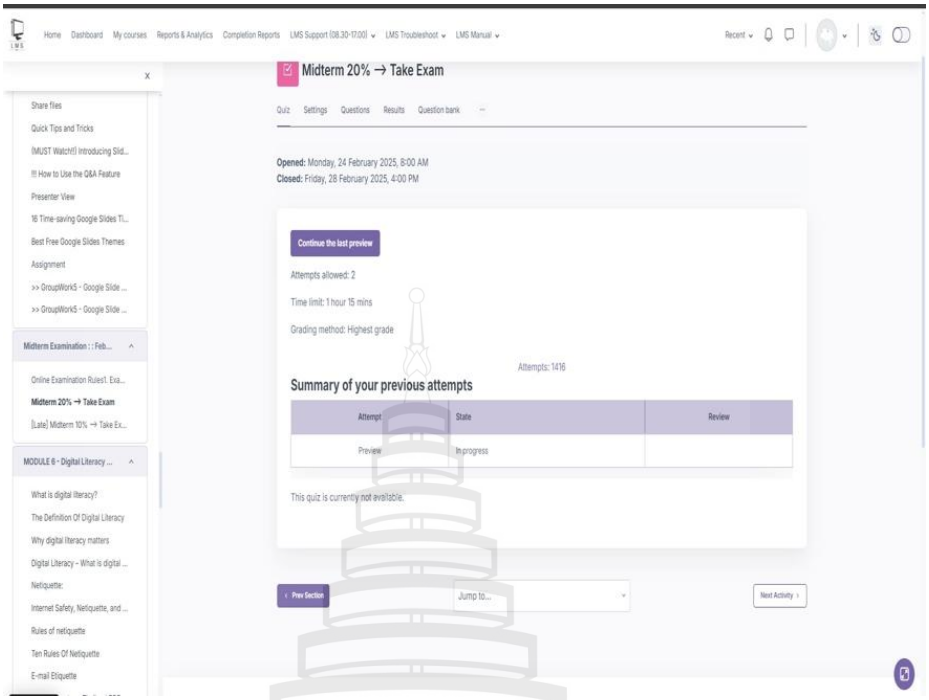


Figure 4.5 LMS Pre-Test Page

On the assignment page, after studying everything on the test page, press submit assignment. The page will allow students to submit their work by submitting it as a file or link for submission. There will be a feature to attach files, insert links, and comments for submitting assignments.

1. Exam 2 Page

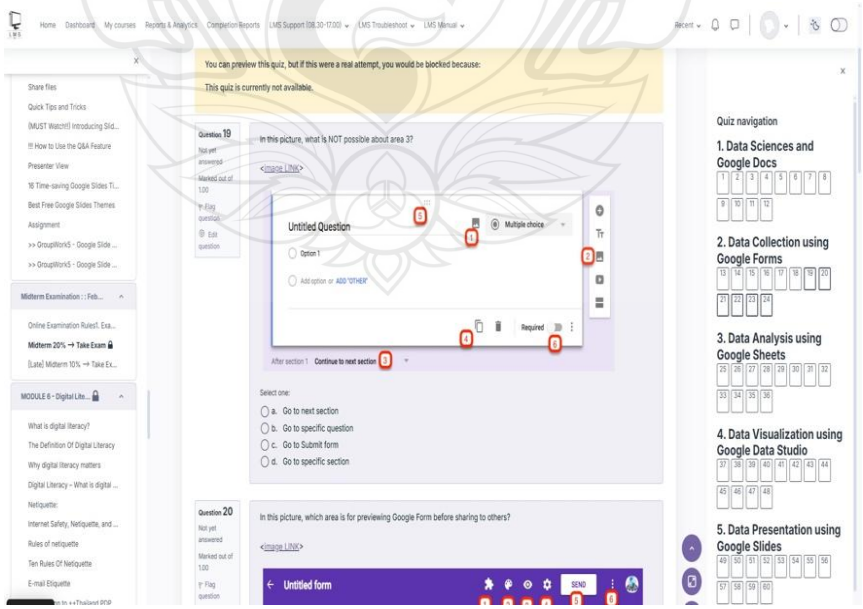


Figure 4.6 LMS Exam Page with Photo

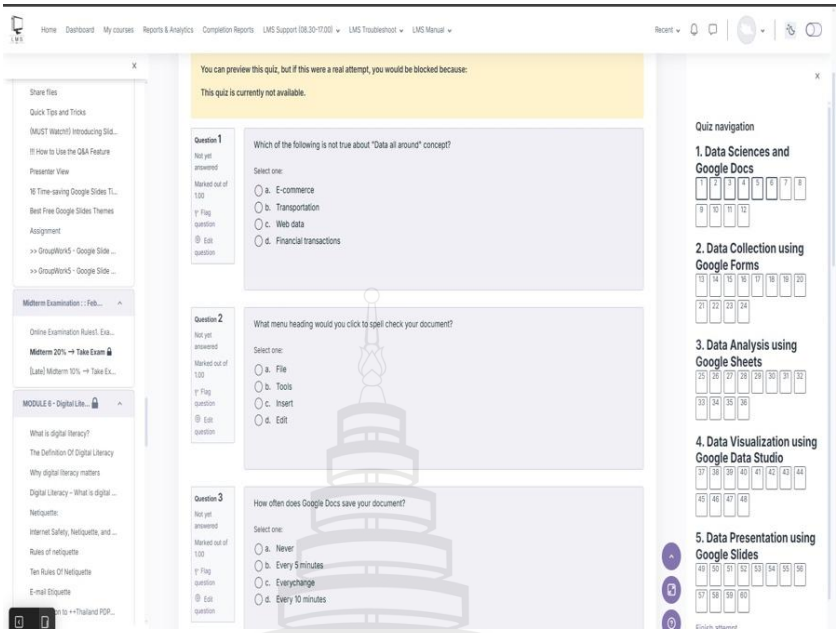


Figure 4.7 LMS Exam Page

On the exam page before entering the exam page, the format is similar to the assignment page, but there is no submission, but there is a button to press to start the exam, there are various rules for the exam, and after pressing to start the exam, the questions and answers are multiple choice (a-d), with some questions requiring pictures to accompany the answers, when the time is up before the entire exam is finished, it will be saved and submitted immediately. If finished before the time, you can press to submit the exam, and the answers will be saved automatically.

Figure 4.8 LMS Header

Header: “Login” Profile, Logo, contact, home, dashboard, my course, support, troubleshoot, manual, recent and notification

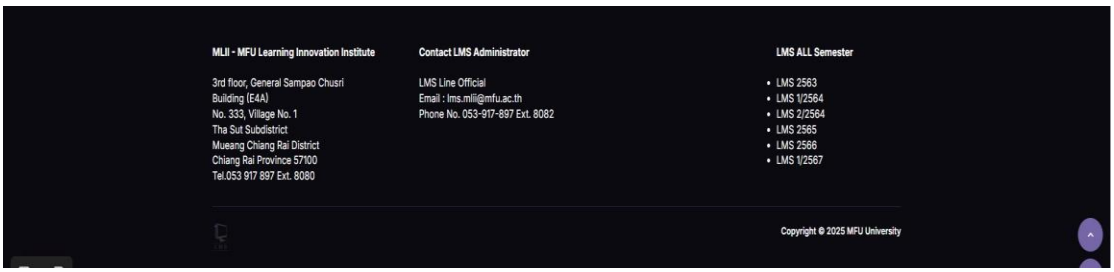


Figure 4.9 LMS Footer

Footer: Contact info (address, phone/fax), links to social media and key university divisions.

4.2.2 MFU Official Website

Mae Fah Luang University's official website, which has passed the WCAG assessment in 2023 and received the Thailand Digital Accessibility Award 2023 from the NSTDA the website must pass at least AA level. By MFU official, we have checked the Homepage, News Page, Announcement Page, Activity News Page, About Page and Course Page. I have selected pages that cover all content for people with disabilities (https://www.mfu.ac.th/mfu-landing-page.html).

1. Homepage

Figure 4.10 MFU Homepage

Serves as the official portal for Mae Fah Luang University, aimed at prospective students, current students, faculty, and visitors. Provides access to essential information such as admission details, academic programs, international exchange, news, and announcements.

Multi-language toggle (EN/TH). Font size adjustment (A- / A+ icons). Responsive dropdown navigation covering key sections (About MFU, Schools, Admission, Current Students, Visitors).

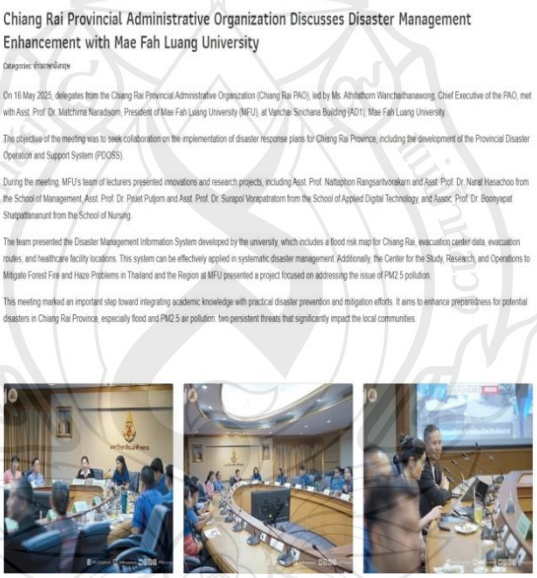
Main content presentation:

Featured news with headings, images, publication date, author, and view count (e.g., “Call for application...” and “MFU Ranked…” posts).

QR code for quick access.

Interactive map of campus (“MFU Map” section)

2. News Page


Chiang Rai Provincial Administrative Organization Discusses Disaster Management Enhancement with Mae Fah Luang University

Categories: ข่าวความร่วมมือ

On 16 May 2025, delegates from the Chiang Rai Provincial Administrative Organization (Chiang Rai PAO), led by Ms. Athitadhorn Wanchathanawong, Chief Executive of the PAO, met with Asst. Prof. Dr. Matchima Naradasorn, President of Mae Fah Luang University (MFU), at Vanchai Sirichana Building (AD1), Mae Fah Luang University.

The objective of the meeting was to seek collaboration on the implementation of disaster response plans for Chiang Rai Province, including the development of the Provincial Disaster Operation and Support System (PDOSS).

During the meeting, MFU's team of lecturers presented innovations and research projects, including Asst. Prof. Nattaphon Rangsantivorakarn and Asst. Prof. Dr. Narat Hasachoo from the School of Management, Asst. Prof. Dr. Pirjet Putjorn and Asst. Prof. Dr. Surapol Vorapatratorn from the School of Applied Digital Technology, and Assoc. Prof. Dr. Boonyapat Shatpattinanunt from the School of Nursing.

The team presented the Disaster Management Information System developed by the university, which includes a flood risk map for Chiang Rai, evacuation center data, evacuation routes, and healthcare facility locations. This system can be effectively applied in systematic disaster management. Additionally, the Center for the Study, Research, and Operations to Mitigate Forest Fire and Haze Problems in Thailand and the Region at MFU presented a project focused on addressing the issue of PM2.5 pollution.

This meeting marked an important step toward integrating academic knowledge with practical disaster prevention and mitigation efforts. It aims to enhance preparedness for potential disasters in Chiang Rai Province, especially flood and PM2.5 air pollution, two persistent threats that significantly impact the local communities.

Figure 4.11 MFU News Page

On this page, there is information about news on the topic that we have selected.

3. Announcement Page

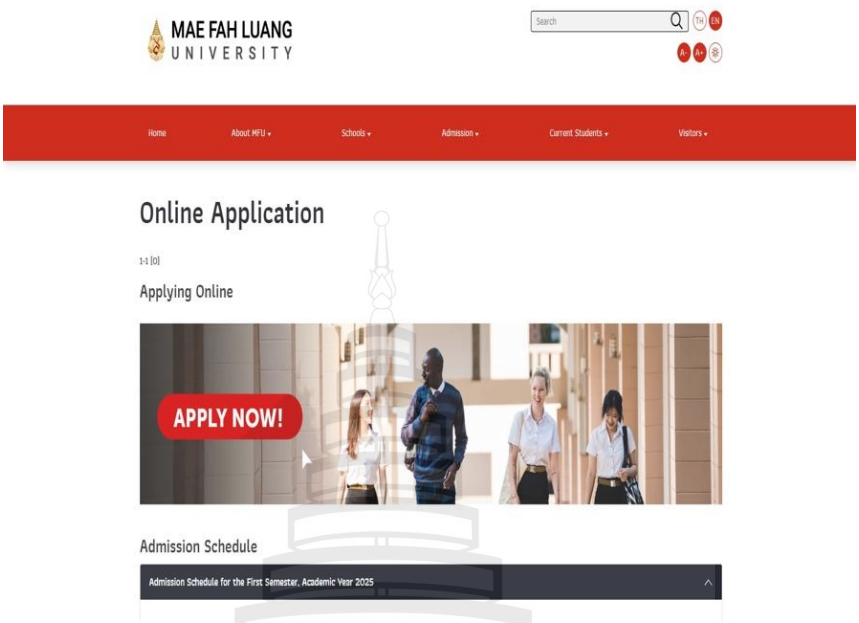


Figure 4.12 MFU Announcement Page

All notification pages about the university such as Applying Online, Admission Schedule, Documents Required for Admission, Academic Calendar.

4. Activity News Page

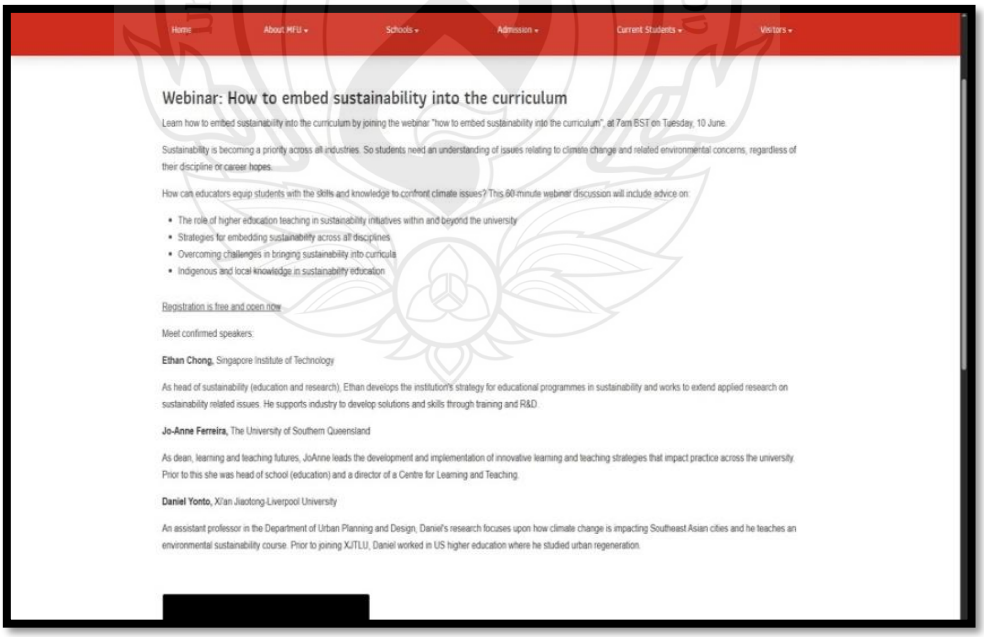


Figure 4.13 MFU Activity Page

A page about upcoming events or a recap of past events.

5. About Page

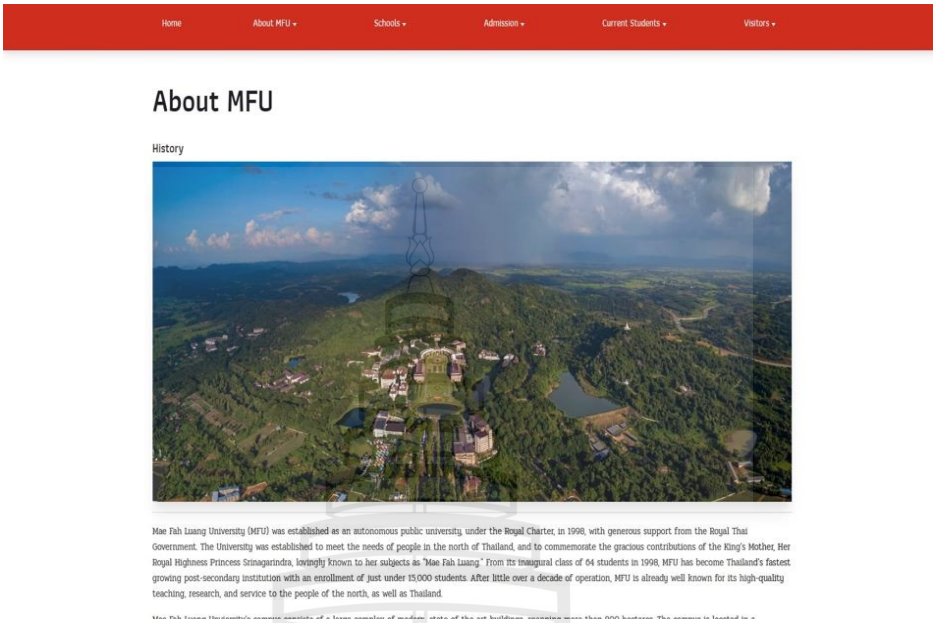


Figure 4.14 MFU About Page

The page provides information about the university, its history, Philosophy, Vison and Mission.

6. Course Page

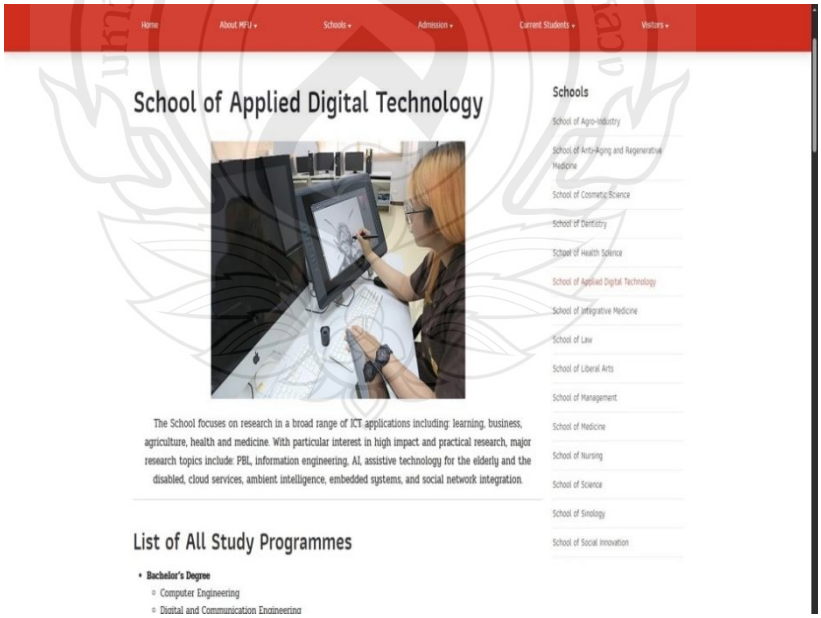


Figure 4.15 MFU Course Page

The page provides information about the school, List of All Study Program and a list of faculty members, email, contact numbers and Contact School.

Figure 4.16 MFU Header

Header: Language switcher (TH/EN), font size toggles, skip-to-content links, and main navigation menu with multi-level dropdown sections (e.g., About MFU, Schools, Admission).

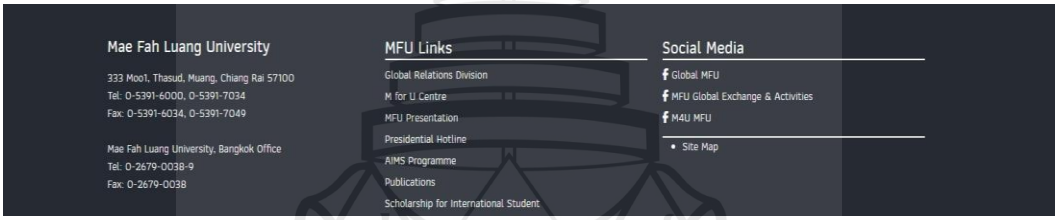


Figure 4.17 MFU Footer

Footer: Contact info (address, phone/fax), links to social media and key university divisions.

4.2.3 Foundation for Children with Disabilities' eLearning System

In this section, I choose an alternative online learning website that is like the MFU LMS website for comparison. Based on our literature review, the online learning website of the "Project for Knowledge management on Disabilities and Rehabilitation in Children and Adults for Application to Capacity Building for Persons with Disabilities" is selected (cite: https://fcdthailand.org/knowledge-management/). It is an inclusive educational website providing accessible online content and developmental tools for children with disabilities and their families. The platform is designed to promote self-care, communication, and social skills, and is supported by a government-backed knowledge management project.

Therefore, the FCD's webpages are selected for auditing on their five pages including the home page, course page, content page, test start page, and content assignment page (https://fcd-elearning.in.th).

1. Homepage

Figure 4.18 FCD's Homepage

Main Content: Course highlight zone with images and information (course name, duration, number of lessons/tests/students)

Course Detail Page: Displays course information, including instructors, lesson list, tests, number of registrants, and participant comments

2. Course Page

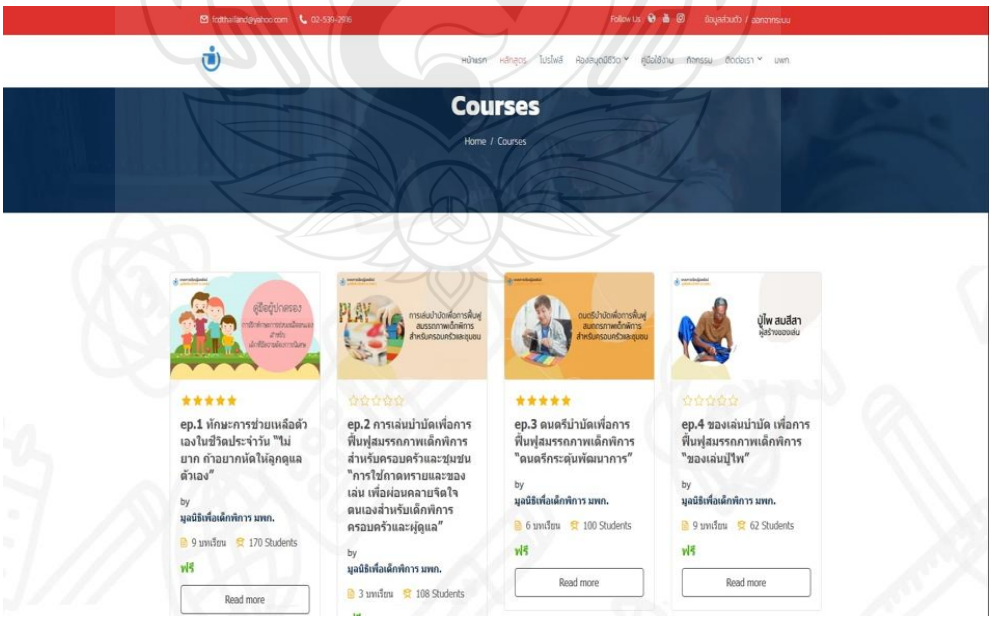


Figure 4.19 FCD's Course page

Introduce the appearance of the various courses Course name, duration of study and details about each lesson

3. Content Page

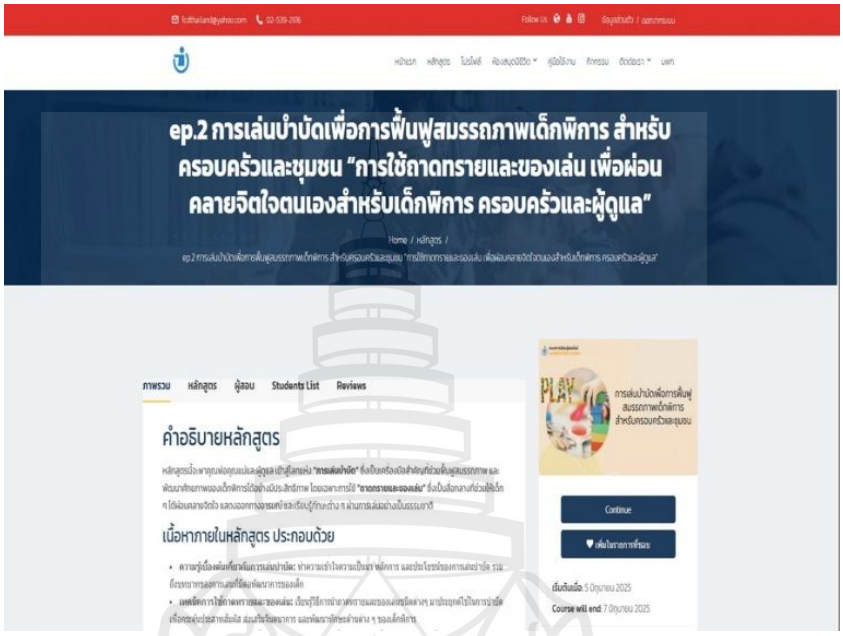


Figure 4.20 FCD's Content Page

This is the content introduction page for the lesson. Overview, content, instructor, students list and reviews. There are features to comment on the lesson, click to start the lesson and add to favorites.

4. Content Assignment Page

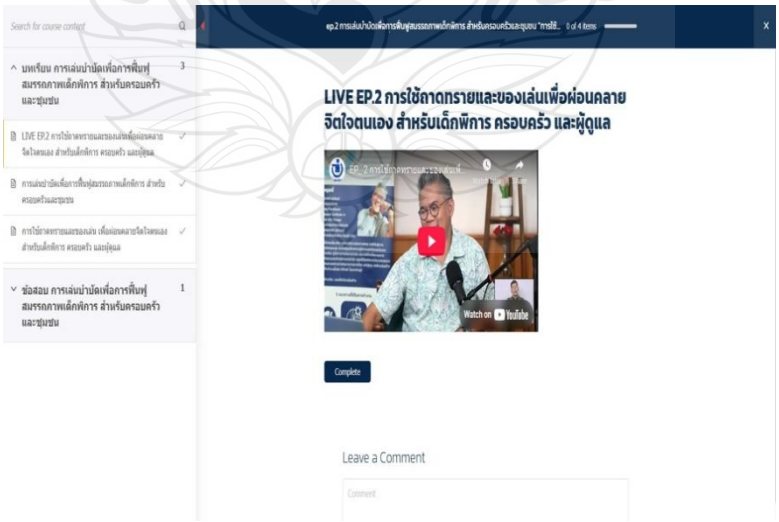


Figure 4.21 FCD's Content Assignment Page VDO

Figure 4.22 FCD's Content Assignment Page PDF Textbook

On this page, after we click on the start test on the content page, this page will have the content that must be studied in that chapter, both video, PDF textbook and after finishing the course, there is a page for the test to do.

5. Test Page

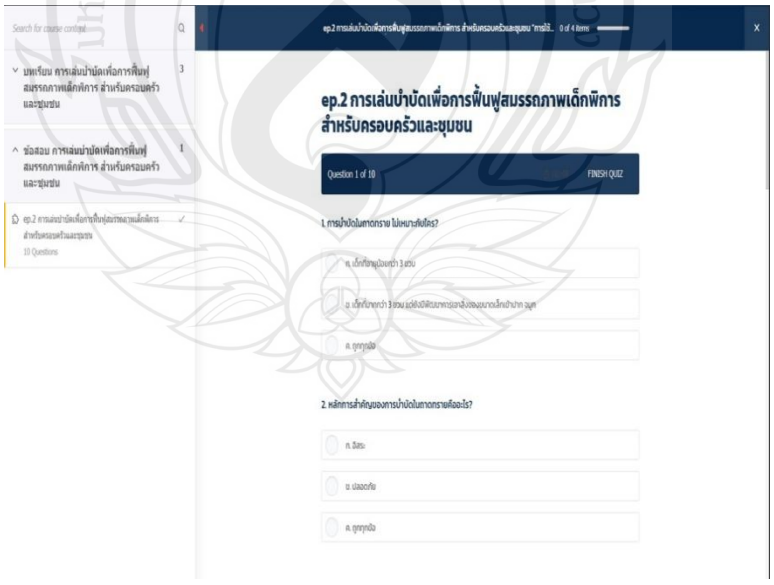


Figure 4.23 FCD's Test Page

On this page, after we have studied all the content from the pre-test page, there will be a test to do by selecting the choices (a-d).

Figure 4.24 FCD's Header

Header: "Login" and "Register" buttons, Foundation logo, contact information (email, phone number), and main menu (Home, Courses, Living Library, User Manual, Contact Us, etc.)

Figure 4.25 FCD's Footer

Footer: Foundation organization information (address, email, phone number), policy link, message that supports people with disabilities, and support information Layout / Components.

4.3 Accessibility Evaluation

The website accessibility was checked according to the Web Content Accessibility Guidelines (WCAG) version 2.1 at levels A, AA using the automated tool WAVE and manual checks in parallel. The analysis focused on the LMS, which was the core of the study. Level AAA has very strict requirements, achieving AAA may

affect UI/UX, WCAG AA is an adequate standard level, and most websites choose only WCAG AA because it balances accessibility and aesthetics of UI/UX, while level AAA is suitable for niche websites and has requirements that are too difficult and strict for general use.

4.3.1 WAVE

WAVE (Web Accessibility Evaluation Tool) is a widely used online tool developed by WebAIM to help authors evaluate the accessibility of their web content. WAVE visually highlights accessibility issues directly on the web page, making it easier to understand where and what the problems are.

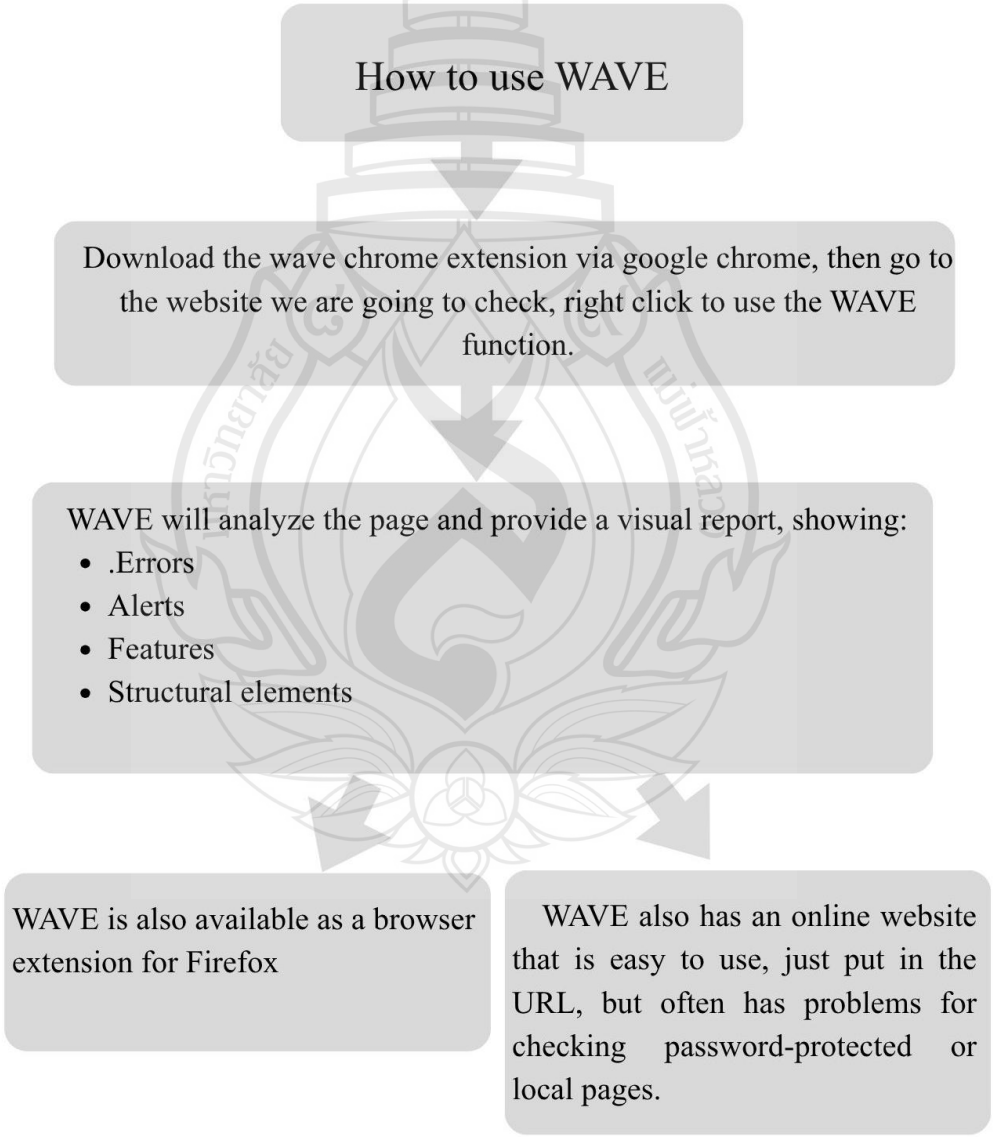


Figure 4.26 How to use WAVE

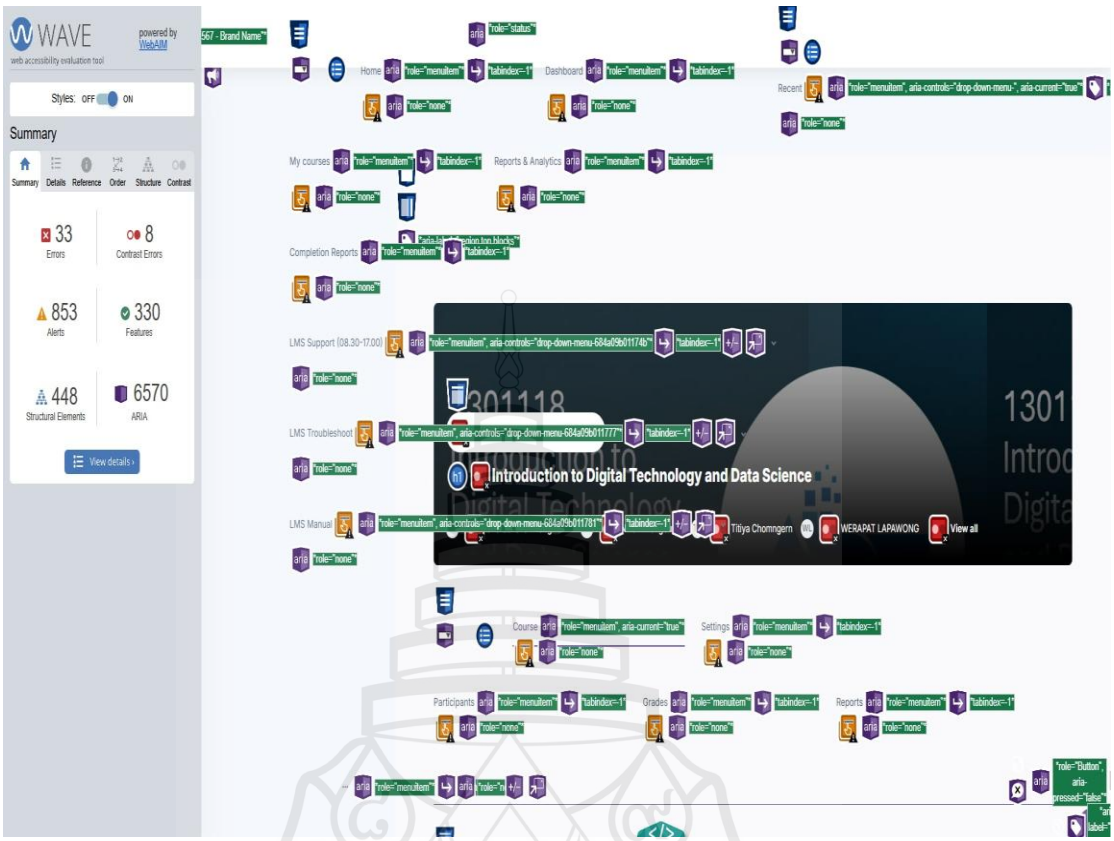


Figure 4.27 WAVE Interface

4.3.2 Manual Check

While automated tools like WAVE are helpful, they cannot detect every accessibility issue. Manual checking is essential to ensure full compliance, especially for WCAG criteria that require human judgment.

1. Manually test accessibility by:
2. Checking alt text and image descriptions
3. Navigating with keyboard only
4. Verifying headings and link purposes
5. Ensuring proper form labels
6. Checking visual and reading order

4.4 Auditing Results

The WCAG breaks down web accessibility into four key principles, collectively known as POUR:

4.4.1 Perceivable – Information and user interfaces must be visible or recognizable, such as alt text, adequate color contrast.

4.4.2 Operable – Users must be able to navigate and use the site in a variety of ways, such as using the keyboard instead of the mouse, and having a clear focus sequence.

4.4.3 Understandable – Content and usability must be easy to understand, such as using clear language and clearly labeled forms.

4.4.4 Robust – The site should be coded to support assistive devices, such as screen readers, and remain functional in the future (Not included in this table, but will contribute to its completeness).

For the LMS system, the auditing results show in Table 4.1. There are 14 criteria audited as pass on the Perceivable domain. There are also 14 criteria passed on the Operable domain. More interestingly, all criteria in the Understandable domain are validated as pass. Finally, only 2 criteria out of 3 passed in the Robust domain.

Table 4.1 LMS

Domain	# of criteria	Passed criteria	Missed Criteria
Perceivable	20	14	6
Operable	17	14	3
Understandable	10	10	0
Robust	3	2	1

For MFU official, the auditing results show in Table 4.2. There are 18 criteria audited as pass on the Perceivable domain. There are 15 criteria passed on the Operable domain. There are 8 criteria passed on the Understandable domain. Finally, Robust domain is validated as pass.

Table 4.2 MFU Official

Domain	# of criteria	Passed criteria	Missed Criteria
Perceivable	20	18	2
Operable	17	15	2
Understandable	10	8	2
Robust	3	3	0

For FCD-eLearning, the auditing results show in Table 4.3. There are 15 criteria audited as pass on the Perceivable domain. There are 11 criteria passed on the Operable domain. All criteria in the Understandable domain are validated as pass. Finally, only 2 criteria out of 3 passed in the Robust domain.

Table 4.3 FCD-eLearning

Domain	# of criteria	Passed criteria	Missed Criteria
Perceivable	20	15	5
Operable	17	11	6
Understandable	10	10	0
Robust	3	2	1

4.5 Results Validation and Analysis

After analyzing the LMS system, a questionnaire was created via Google Forms to summarize the errors found and to solicit feedback from real users as instructors or students.

An example question in the questionnaire is: “Do you agree that the LMS does not have audio descriptions for videos (Audio Description) according to WCAG 1.2.5 Level AA criteria?”

The questionnaire covers all 10+ items that do not pass Level AA, with users answering “agree/disagree” to reflect the perspectives of real users. These survey questions were designed based on the missed criteria that the LMS is not qualified, summarized in Table 4.1. The details of these unqualified criteria can be explained in Table 4.4.

Table 4.4 WCAG 2.1 Missed Criteria by the LMS

Domain	WCAG 2.1 Missed Criteria	Details
Perceivable	1.1.1 Non-text Content	Provide alt text for images and icons.
	1.2.2 Captions (Prerecorded)	Add captions for prerecorded videos.
	1.2.5 Audio Description (Prerecorded)	Include audio descriptions for videos.
	1.3.1 Info and Relationships	Use proper HTML structure and labels.
	1.4.3 Contrast (Minimum)	Ensure text has sufficient contrast.
	1.4.5 Images of Text	Avoid using text within images.
Operable	2.1.1 Keyboard	All functionality must be keyboard accessible.
	2.4.4 Link Purpose (In Context)	Links must clearly describe their purpose.
	2.4.5 Multiple Ways	Provide more than one way to access pages.
Understandable	-	-
Robust	4.1.2 Name, Role, Value	Ensure elements have correct roles and properties.

1. In this study, a total of four experts were invited to participate in the accessibility evaluation survey. The group consisted of four lecturers and two teaching assistants from Mae Fah Luang University. These individuals were selected based on their direct experience with the LMS system and their involvement, making them qualified to assess the accessibility features and usability of the platform.

2. These MFU-LMS users, were course lecturers, teaching assistants, and disabled students. For the invited visually impaired students, they were the second year to fourth-year students, who experienced using screen reader software e.g. JAWS and NVDA during their everyday life. In total, there are four lecturers, two teaching assistants and twelve visually impaired students who were invited to answer the questionnaire and do in-dept interview. The results and analysis of the survey can be summarized as following Table V.

Table 4.5 MFU-LMS Usage Experience Validation on Missed WCAG 2.1's Criteria

Missed WCAG Criteria	Description	Number of Agreed Experts	Agreement Percentage
Level A: WCAG 1.1.1	MFU-LMS lacks alternative text for non-text content, making it inaccessible for screen reader users.	16	88.9%
Level A: WCAG 1.2.2	MFU-LMS does not provide captions for prerecorded video, limiting accessibility for hearing-impaired users.	16	88.9%
Level A: WCAG 1.3.1	MFU-LMS has poor content structure and missing semantic markup, causing difficulties in navigation for assistive technologies.	16	88.9%
Level A: WCAG 2.1.1	MFU-LMS lacks full keyboard accessibility, preventing users from operating all functions without a mouse.	15	83.3%
Level A: WCAG 2.4.4	MFU-LMS does not provide descriptive link text, making it unclear where links will lead.	16	88.9%
Level A: WCAG 4.1.2	MFU-LMS has incomplete or invalid name, role, and value assignments, creating problems for assistive technologies.	15	83.3%
Level AA: WCAG 1.2.5	MFU-LMS lacks audio descriptions for video content, reducing accessibility for visually impaired users.	17	94.4%
Level AA: WCAG 1.4.3	MFU-LMS does not maintain sufficient color contrast between text and background, making it difficult to read for low-vision users.	14	77.8%
Level AA: WCAG 1.4.5	MFU-LMS uses images of text instead of actual text, limiting scalability and accessibility.	17	94.4%

4.6 Suggestion to Improve Each Website

To make the LMS website to meet with the WCAG level AA compliant, there are 10 things that need to be improved in the MFU LMS website, and here are some recommendations:

4.6.1 Non-text Content

For the WCAG 1.1.1, the website must add meaningful alt text to all informative images. For icons, infographics, and input images (e.g., buttons), ensure they have labels or descriptions.

4.6.2 Captions (Prerecorded)

For the WCAG 1.2.2, the website must provide synchronized captions for all prerecorded videos with speech.

4.6.3 Info and Relationships

For the WCAG 1.3.1, the website must Use proper HTML structure (e.g., headings, lists, tables) to convey relationships.

4.6.4 Keyboard

For the WCAG 2.1.1, the website must Make sure all interactive elements (e.g., buttons, links, menus, modals) are fully usable with just a keyboard (tab, enter, arrows).

4.6.5 Link Purpose (In Context)

For the WCAG 2.4.4, the website must Make sure all links make sense out of context.

Use descriptive text that tells users where the link will take them.

4.6.6 Name, Role, Value

For the WCAG 4.1.2, the website must Use proper ARIA roles and attributes for custom widgets. Make sure assistive technologies can understand the element's name (label), role (function), and current value (e.g., sliders, checkboxes, dropdowns).

4.6.7 Audio Description (Prerecorded)

For the WCAG 1.2.5, the website must Provide audio descriptions for videos with important visual content not explained in speech.

4.6.8 Contrast (Minimum)

For the WCAG 1.4.3, the website must Ensure text and images of text have a contrast ratio of at least 4.5:1 against the background.

4.6.9 Images of Text

For the WCAG 1.4.5, the website must Avoid using images to display text unless necessary.

4.6.10 Multiple Ways

For the WCAG 2.4.5, the website must Provide at least two ways to locate a page within the website.

These will improve the accessibility for users with cognitive disabilities or screen reader users.

4.7 Summary

I evaluated the accessibility of three websites — the MFU Official Website, the LMS (Learning Management System), and the FCD eLearning website — using WCAG 2.1 Level A and AA guidelines. The process included both automated testing tools (such as WAVE) and manual checks. I then summarized the accessibility issues and created a Google Form to collect feedback from real LMS users. The focus was on key user pages: Homepage, Course Page, Exercise Page, Assignment Page, and Exam Page.

The LMS website showed the most accessibility issues, particularly under the Perceivable and Operable principles. The most common problems were missing alt text (1.1.1), lack of proper keyboard navigation (2.1.1), and insufficient color contrast (1.4.3). In contrast, the MFU Official Website passed almost all WCAG AA criteria, making it a good benchmark for improvement. User feedback from the form also confirmed that the LMS needs updates to better support users with disabilities.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1 Overview

This chapter presents the conclusion, discussion of the results, and suggestions based on the evaluation of web accessibility for three websites: The Mae Fah Luang University Official Website, the LMS (Learning Management System), and the Online Learning Website (FCD E-learning). The evaluation was conducted using the WCAG 2.1 Level AA guidelines, both by automated tools and manual inspection.

5.2 Summary of Findings

The research followed the methodology proposed in Chapter 3, and the results were reported in Chapter 4. The key findings are summarized as follows: The MFU Official Website fully passed WCAG 2.1 Level AA.

The LMS had several accessibility issues and became the focus of further user testing and feedback. The Online Learning Website also had missing criteria in key areas. An online survey (Google Form) was conducted using questions based on the WCAG 2.1 AA checklist It was distributed to 18 invited participants, including four lecturers, two teaching assistants, and twelve visually impaired students with experience using the University Learning Management System (LMS). They were asked to verify the issues found by automated tools and comment on the user experience.

5.3 Discussion

After evaluating the LMS website using WCAG 2.1 Level AA guidelines, several significant accessibility issues remained. For example, many images lack alternative text, some links lack meaningful descriptions, and some interface components are not accessible using a keyboard alone. These limitations pose significant barriers to users with disabilities, especially those who rely on assistive technology such as screen readers.

Compared to MFU's official website, which meets most WCAG Level AA requirements, the LMS platform still needs further improvement. The evaluated pages, including the homepage, course pages, exercises, assignments, and exams, were considered the core experience for students, but many elements were found to be inaccessible or confusing. Feedback from the LMS user survey also pointed to issues such as unclear navigation and missing labels on forms.

5.4 Recommendations

The University-LMS identified serious accessibility issues under WCAG 2.1 Level AA, including missing alternative text, unclear links, and limited keyboard accessibility, which were reported during the evaluation. These barriers affect the disabled users more when accessing the University's official website, which complies more closely with the WCAG 2.1 level AA. The invited users' agreement survey also highlighted unclear navigation and missing form labels in the University-LMS, and their feedback further emphasized the need for immediate improvements to better support accessibility for visually impaired students. To improve accessibility and comply with WCAG 2.1 Level AA, we recommend the following changes:

5.4.1 Add clear, descriptive alternative text for all images and icons.

5.4.2 Ensure that all form fields have relevant labels.

5.4.3 Adjust text color contrast to meet minimum contrast requirements.

5.4.4 Enable keyboard navigation across all sites.

5.4.5 Fix any empty or broken links and check for missing ARIA roles or attributes.

These actions will help make your LMS more inclusive for users with diverse needs and ensure it meets accepted accessibility standards.

5.5 Future Works

One limitation of this study is the small number of participants. Although this study involved only eighteen invited users, the provided feedback may not represent the perspectives of all users.

Future studies should include a wider range of users, including those with visual or mobility impairments, and test accessibility using screen readers such as NVDA or Voiceover. Expanding the assessment to include more advanced WCAG levels, such as AAA, may also be beneficial.

Future research could also focus on developing prototypes or design guidelines to support institutions in building more accessible educational platforms from the ground up.

REFERENCES

Ahmad, S., & Hashim, N. (2022). Evaluating accessibility of higher education portals in Southeast Asia using WCAG 2.1 standards. *Journal of Educational Technology and Accessibility, 8*(2), 41–57.

Al-Khalifa, H. S., Al-Ajlan, A. A., & Al-Mutairi, S. (2020). Accessibility assessment of university e-learning systems: A WCAG 2.1 compliance evaluation. *International Journal of Emerging Technologies in Learning (iJET), 15*(12), 87–101.

Apple Inc. (2025). *Accessibility | Apple Developer Documentation.* https://developer.apple.com/accessibility

Asniarti, A., & Iskandar Muda, I. (2019, May). The effect of computer assisted audit tools on operational review of information technology audits. In *Proceedings of the 1st International Conference on Social Sciences and Interdisciplinary Studies (ICSSIS 2018)* (Vol. 208, pp. 23-27). Atlantis Press. https://doi.org/10.2991/icssis-18.2019.5

Bigham, J. P., Prince, C. M., & Ladner, R. E. (2008). *Addressing performance and security in a screen reading web application that enables accessibility anywhere.* In *Proceedings of the Eighth International Conference on Web Engineering* (pp. 273–284). IEEE. https://doi.org/10.1109/ICWE.2008.47

Burton, C. (2022). *Sell Courses, Communities, Memberships, and More With Thinkific.* Thinkific.com. https://www.thinkific.com

Darren, T., Ritesh, C., & Jo, L., (2020). *Learning Management Systems, An Overview.* https://www.researchgate.net/publication/335463920

Elda, Y., & Ledia, K. (2021). *Challenges of Students in Online Learning.* https://www.researchgate.net/publication/359154932_Challenges_of_Students_in_Online Learning

Freedom Scientific. (2018). *JAWS 2018 Enhancements.* https://support.freedomscientific.com/downloads/jaws/JAWSWhatsNew?version=2018

Freire, A., & Paiva, D. (2007). Using screen readers to reinforce web accessibility education. *ACM SIGCSE Bulletin, 39*, 82–86. https://doi.org/10.1145/1269900.1268810

Freire, A. P., de Mattos Fortes, R. P., Barroso Paiva, D. M., & Turine, M. A. S. (2021). *Using screen readers to reinforce web accessibility education*. *ACM SIGCSE Bulletin*, *39*(3), 252-256. https://doi.org/10.1145/1269900.1268810

Paola, S., Silvia, M., Ludovico, A., Matteo, B., (2012). *Integrating Manual and Automatic Evaluations to Measure Accessibility Barriers*. http://doi.org/10.1007/978-3-642-31522-0_59

iSpring Solutions. (2025). *Top 20 learning management system (LMS) features.* https://www.ispringsolutions.com/blog/lms-features

Janmaimool, P., & Nunsunanon, S. (2021). *Online vs. Face-to-Face Lecture Courses: Factors Impacting the Effectiveness of Online Learning. Preprints,* 202107.0306.v1. https://doi.org/10.20944/preprints202107.0306.v1

Bigham, J. P., Prince, C. M., & Ladner, R. E. (2008). *WebAnywhere: A screen reader on-the-go*. In Proceedings of the International Cross-Disciplinary Conference on Web Accessibility (W4A 2008) (pp. 21–22). https://webinsight.cs.washington.edu/papers/webanywhere.pdf

Kearney-Volpe, C., & Hurst, A. (2021). *Accessible web development: Opportunities to improve the education and practice of web development with a screen reader. ACM Transactions on Accessible Computing (TACCESS), 14(2),* https://doi.org/ 10.1145/3458024

Kumari, S., Gautam, H., Nityadarshini, N., Das, B. K., & Chaudhry, R. (2021). Online classes versus traditional classes? Comparison during COVID-19. *Journal of Education and Health Promotion, 10*(457). https://doi.org/10.4103/jehp.jehp_317_21

Lee, C. H., & Chen, J. Y. (2023). Accessibility evaluation in learning management systems for inclusive education: A case study of Moodle implementations in East Asia. *Universal Access in the Information Society, 22*(3), 611–627.

Lomellini, A., Lowenthal, P., Snelson, C., & Trespalacios, J. (2025). Accessible and inclusive online learning in higher education: A review of the literature. *Journal of Computing in Higher Education, 37*, 1306–1329. https://doi.org/10.1007/s12528-024-09424-2

Mae Fah Luang University. (n.d.). *Student Wellness and DSS Department: Supporting students with disabilities.* https://studentaffairs.mfu.ac.th/std-2820/std-2900.html

Mae Fah Luang University. (2023, May 29). *MFU website wins Thailand Digital Accessibility Award 2023 for WCAG compliance. MFU News.* https://www.mfu.ac.th/news/newsdetail/detail/News/18998.html

Mae Fah Luang University. (2025). *MFU Online Learning System.* https://online-learning.mfu.ac.th

Marc, A. F., Maria, J. C. G., Miguel, A. C. G., Francisco, J. G. P., & Charles, S. (2010). Interoperability for LMS: The Missing Piece to Become the Common Place for Elearning Innovation. *Conference Paper in International Journal of Knowledge and Learning*. https://doi.org/10.1007/978-3-642-04754-1_30

Megan Binder. (2024). *7 Top Challenges with Online Learning For Students (and Solutions).* https://www.thinkific.com/blog/challenges-with-online-learning/

Microsoft. (2025). *Accessibility – Trust Center.* https://www.microsoft.com/en-us/trust-center/privacy/accessibility

Ministry of Social Development and Human Security. (2020, March 31). *Social Development and Human Security Data.* https://www.m-society.go.th/ewtadmin/ewt/MSO_ENG_NEW/home.php

Najmee, N. A. A., Mohammed, Z., Rahman, M. H. A., Fadzil, N. M., Ludin, A. F. M., & Hassan, R. (2025). Classroom settings for visually impaired schoolchildren: A scoping review. *PLOS ONE, 20*(2), e0318871. https://doi.org/10.1371/journal.pone.0318871

New England Low Vision and Blindness. (2025). *Adapting the Classroom for Children with Low Vision: Practical Strategies for Inclusive Learning.* https://nelowvision.com/wp-content/uploads/2025/07/Adapting-the-Classroom-for-Children-with-Low-Vision_-Practical-Strategies-for-Inclusive-Learning.pdf

Odeh, K. B., & Lach, L. M. (2024). *Barriers to, and facilitators of, education for children with disabilities worldwide: A descriptive review. Frontiers in Public Health, 11*, 1294849. https://doi.org/10.3389/fpubh.2023.1294849

Ryann K. & Ellis. (2009). *A Field Guide to Learning Management Systems. published by the American Society for Training & Development (ASTD). © 2009, ASTD Inc.*https://assets.td.org/m/788c366c54cfed87/original/Microsoft-Word-LMS_fieldguide_2009.pdf

Sandhya S and Sumithra D. (2011) *Accessibility evaluation of websites using screen reader* https://www.researchgate.net/publication/254009312_Accessibility_evaluation_of_websites_using_screen_reader

Sooyoung. J., & Jun. H., H. (2019). *An Efficient LMS Platform and Its Test Bed. Electronics* 2019, *8*(2), 154; https://doi.org/10.3390/electronics8020154

Thailand Institute of Scientific and Technological Research (TISTR). (2023, May 29). *TISTR wins Thailand Digital Accessibility Award 2023 for WCAG-compliant website. TISTR PressCenter.* https://www.tistr.or.th

Thailand Association of the Blind. (n.d.). Publishing program: Program PPA Tatip [Program-release page]. https://www.tab.or.th

Tartari, E., & Kashahu, L. (2021). *Challenges of students in online learning.* December 2021. Kultura i Edukacja 134(4):229-239. https://doi.org/10.15804/kie.2021.04.13

User1st. (2025). *How Labels Create Confusion for Screen Reader Users. User1st Blog.* https://blog.user1st.com/blog/how-labels-create-confusion-for-screen-reader-users

Vaughn, L. M., & Jacquez, F. (2020). Participatory Research Methods – Choice Points in the Research Process. *Journal of Participatory Research Methods, 1*(1). https://doi.org/10.35844/001c.13244

Vigo, M., Brown, J., & Conway, V. (2021). Measuring web accessibility beyond compliance: Towards user-centered evaluation frameworks. *ACM Transactions on Accessible Computing (TACCESS), 14*(2), 1–28.

William R. Watson and Sunnie L., Watson. (2007). *An Argument for Clarity: What are Learning Management Systems, What are They Not, and What Should They Become?* January 2007 TechTrends 51(2):28-34. https://doi.org/10.1007/s11528-007-0023-y

Waisath, W., McCormack, M., Stek, P., & Heymann, J. (2023). *Dismantling barriers and advancing disability-inclusive education: An examination of national laws and policies across 193 countries. World Policy Analysis Center, UCLA Fielding School of Public Health.* https://www.worldpolicycenter.org

WebAIM. (2025). *WAVE Web Accessibility Evaluation Tool.* https://wave.webaim.org

World Wide Web Consortium (W3C). (2018). *Web Content Accessibility Guidelines (WCAG) 2.1. W3C Web Accessibility Initiative.* https://www.w3.org/WAI/standards-guidelines/wcag

World Wide Web Consortium (W3C). (2025, May 6). *Web Content Accessibility Guidelines (WCAG) 2.1. W3C Recommendation.* https://www.w3.org/TR/WCAG21

Yin, A., Sogani, R., Oewel, B., Phan, K., Park, J. S. Y., Yeo, M. A., Yazzolino, L. A., Arcos, K., Abdolrahmani, A., Gilbert, M. D., & Branham, S. M. (2024). *"Malicious" pictorials: How alt text matters to screen reader users' experience of image-dense media*. In Proceedings of the 2024 ACM Designing Interactive Systems Conference (DIS '24) (pp. 1262–1274). https://doi.org/10.1145/3643834.3660747

CURRICULUM VITAE

NAME Piyarat Thammachokmongkol

EDUCATIONAL BACKGROUND

2008 Bachelor of Liberal Art
Language for Development
Prince of Songkla University

WORK EXPRERINCE

2013 – Present Administrative Officer
Disability Support Service (DSS), MFU

2009 – 2012 Security Department Store
Tesco Lotus Hatyai, Songkhla

2008 – 2009 Guest Service Agent
The Passage Samui Resort and Spa, Surat Thani

PUBLICATION

Piyarat, T., Werapat, L., & Worasak, R. (2025). *Evaluating online content accessibility using WCAG 2.1: A case study of university platforms and an e-Learning system for students with visual impairments*. In Proceedings of The 9th International Conference on Information Technology (InCIT2025) (IEEE Conference Record No. 66780, pp. 576–581). Phuket, Thailand. https://incit2025.computing.psu.ac.th/proceedings/