Assistive Technology to Maximize Learning Opportunities for People with Disabilities

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ABSTRACT
A growing number of universities are utilizing online learning systems such as Blackboard to enhance their educational process. Students should be able to use all the features of the online learning system, despite their disabilities including those with visual impairments. Visually impaired students are not included in the Blackboard, and this can affect their learning ability and sense of belonging. This research focuses on improving accessibility, reducing time, and increasing the quality of Blackboard for visually impaired users using Keyboard Shortcuts. Two process models have been created using the Bizagi Modeler. One describes the current process while the second describes the process redesign after the intervention of Assistive Technology using Keyboard Shortcuts. The evaluation was conducted using time analysis simulation for both processes. The results show that keyboard shortcuts improve by 22% the process of the inclusion of visually impaired students with their colleagues, which increases their learning quality and reduces the time and effort spent when they participate.

General Terms
Disabilities, Assistive technology, Blackboard, hearing-impaired, Bizagi Modeler, simulation

Keywords
Business Process Management (BPM), Student disabilities, e-learning, visual disabilities, Assistive technology.

1. INTRODUCTION
The Internet has simplified many mundane tasks, such as meetings and communication, news, and education. In the last two decades, Internet technology has significantly impacted education and the method by which information is presented on web pages has gained increasing importance in the field of education. As a result, many universities have adopted Blackboard's learning management system, which has proven to be an effective educational tool. However, even though the Internet has made life much easier for most people, people with visual disabilities face challenges while browsing websites' pages due to accessibility barriers. The accessibility guidelines emphasize the importance of providing intelligible pages that facilitate access to all online resources by ensuring that all users with various disabilities have equal access to web pages. It is particularly important to follow these guidelines because e-learning systems are now widely adopted for people with disabilities [1]. For the visually impaired to become independent and productive adults, it is imperative that they have access to information on an equal basis. This paper presents a suggested model for improving the existing system. An improvement has been suggested that contributes to reducing the problems for students who are visually impaired or blind that use Blackboard. Visually impaired people cannot locate or see the mouse pointer on a screen. In this case. This proposal is to add a new Assistive Technology. Which is adding a keyboard shortcut to the system that will enhance the accessibility and usability for students with visual disabilities. This keyboard shortcut is attached to the system to help the students to participate in the course session more efficiently and easily. This impacts participating students with disabilities so that they can participate easily and increases their contribution in the online class which increases understandability and learnability for the course and takes off the barriers in participating in the session.

The primary goal of Business Process Management (BPM) is to enhance business processes [2]. This paper uses BPM approaches to enhance time and quality in the Blackboard system for students with visual disabilities. This solution was modeled and simulated using Bizagi Studio. An 'As-is' model has been developed to demonstrate the current usage of Blackboard. Then, a 'To-be' model has been created to illustrate how keyboard shortcuts will improve the process of help control. Afterward, a time analysis simulation was performed on the two models to compare the improvements in the participation process in the Blackboard system for students with visual disabilities. This solution helps to make the participation process in session easy and increases their contribution online. The rest of the paper is presented as follows: Section one is the introduction to this proposed model. The literature review is discussed in section two. Section three discusses the BPM methodology. Results and discussions are in section four. Finally, the conclusion is presented in section five.

2. LITERATURE REVIEW
In this section provides several related studies of e-learning for students with disabilities and some contributions to improving e-learning for students with disabilities. It has been divided into two parts. The first part indicates the studies that focused on investigation and the importance of selecting the appropriate Assistive technologies for disabilities. The second part demonstrates studies where assistive technology has been used and implemented in the real world.

2.1 Investigation and Evaluation
Misyana et al [3] presented an investigation into the challenges

faced by students with special needs who study through ODL at higher education institutions in Malaysia. This paper utilized an online survey to collect challenges. Based on their findings, several factors contributed to the challenges faced by students with special needs in ODL. A parent's familiarity with technology and ability to deal with their child's emotions are crucial factors in assisting their child in ODL, while the instructors were not adequately prepared to work with special needs students.

Raziye [4] proposed this study to present a literature review that discusses the use of assistive technologies in the education process of students with special educational needs. As a result of this research, he found that AT facilitates communication for students with special educational needs in a variety of environments and situations, and different types of assistive technology can be used to facilitate successful outcomes in the case of students who have difficulty writing.

Rufus et al [5] discussed the various types of assistive technology devices that were designed to solve problems related to writing, reading, listening, and mathematics of children with learning disabilities. Additionally, they pointed out that it is important to select the right technology tools for children with learning disabilities. They found that AT could provide support for the teaching of instruction to children with special needs and the appropriate use of AT depended on the skills problem.

Natasha et al [6] examined the impact of COVID-19 on users of assistive technology. To collect information about the sample, they interviewed AT users and their families. According to the study results, the sample consisted of 35 men and 38 women who described their lives and the reasons for using AT during COVID-19. Also, they found Southeast Asia had an impact on using AT during COVID-19.

Karen [7] illustrates some of the possibilities that technological innovations can provide to school students with learning disabilities. The findings indicate that studies have shown that word recognition plays a key role in reading comprehension and that voice recognition software may benefit students with writing disabilities.

Aderonke Soetan, et al. [8] investigated the self-efficacy of students with disabilities in the use of assistive technology to see if they can study just as normal students but lack other capabilities and not intelligence. A sample of 250 hearing-impaired students of the institution was randomly selected for the study. The audiometer was found to be the most functional Assistive technology for students to determine which AT is appropriate for them.

Baiju Thomas, et al. [9] illustrated the importance of selecting the appropriate Assistive technologies for children with disabilities and providing instructional guidance for teaching assistants in the classrooms. They focus on AT tools for Reading, Writing, Listening, and Mathematical skills.

Zahida Chebchoub, et al. [10] provide insight and analysis of the attitudes of disability students regarding the services available to them at United Arab Emirates University (UAEU).

Aleksandra Królak, et al. [11] identified the accessibility issues in MOOCs "Coursera" for blind learners who use screen readers to interact with computers and mobile devices. Data was collected from participants after being asked to complete a 4-week MOOC course offered by Coursera to find the issues.

Donatella Rita Petretto et al. [12] aim to examine papers that focus on the benefits and drawbacks of using distance learning and online courses for students with learning disabilities. They conducted a review of the literature to determine how e-learning, distance learning, and learning disabilities are related. The research indicates that there is an agreement regarding the importance of paying close attention to the accessibility of websites, platforms, and learning materials as well as the need to create a model that can consider individual learning differences.

Fernández-Batanero et al. [13] examine studies that have been done on the effect of assistive technology on the inclusion of students with disabilities. By collecting all relevant scientific research that aimed at evaluating Assistive Technology's influence on enhancing the inclusion of students with disabilities. Additionally, VOSviewer software has been used to visually represent social network analysis techniques. The findings indicate that these tools are suitable instruments for fulfilling students' educational needs during the learning process, as well as for ensuring their accessibility and inclusiveness.

Jamilah M. Alamri et al. [14] conducted an evaluation of the Madrasti platform in Saudi Arabia in terms of usability and content accessibility. A total of 5 main pages were evaluated. Nielsen's usability guidelines were utilized to evaluate the platform's usability, and Madrasti's content accessibility was assessed according to WCAG 1.0. The results demonstrate a relationship between the number of accessibility errors and the usability assessment's results, demonstrating that the platform's developers violated the most crucial development checkpoints. (i.e., the developers of the platform do not follow usability and accessibility standards). Moreover, due to its inaccessibility, the Madrasti platform is unusable for some users with disabilities.

Sean Smith et al. [15] analyze parents' perceptions and experiences regarding fully online learning for their children with disabilities. The parent participants were interviewed via videoconferencing and telephone in semi-structured interviews. Using interviews, they explored current educational practices, identified potential barriers and benefits for students with disabilities, and investigated parental and child experiences with fully online enrollment. However, researchers found that online education vendors and schools should better collaborate with parents of students with disabilities to clarify rigid requirements to families and/or adapt them to meet the needs of individual children.

Elshemy and Alzahrani [16] Explorer the experiences of visually impaired students (VIS) in learning and studying English as a foreign language (EFL) in the realm of online education. Based on assessing the reality of learning EFL online by VIS additionally identifies the VISs' challenges in learning English in e-learning and examines the variables affecting VIS experiences while learning EFL through the e-mode. The methodology is a mix of both quantitative and qualitative approaches. The results indicated that the following factors need to be considered: adequate use of assistive technology, involvement of relevant stakeholders, continuous training and improvement of students and adequate training of trainers to use assistive technology and design of adequate and appropriate assessment and teaching methods, Instructors are trained to handle VIS.

Yulia V. Krasavina et al [17] present the result of research related to designing e-courses for deaf and hearing-impaired students, focusing on three main challenges: effective replacement of audio information with its Visual representations that adapt online educational materials to the

specific cognitive processes of deaf students and facilitate their self-study and educational initiative. The Proposed structure of thematic sections of the e-course on technical subjects includes: Each unit starts with the introduction of an e-vocabulary of terms, tests for comprehension of the presented terms, presents the theoretical material in the form of video lectures with subtitles, lecture notes, activity book, step-by-step instructions to perform tasks and additional materials, Gamification tools contribute to students' motivation and involvement.

This paper [18] presents the beneficial features of iPads. To clarify the potential benefits of the use of iPads as assistive technology (AT) for supporting students with disabilities. It provides features such as using a camera to accurately read and describe small details. Texts are also enlarged. It also converts text into speech and vice versa. All these help disabled people access and use their devices more easily. These features can help them improve their vision, hearing, and physical and motor skills.

2.2 Blackboard

Alnfiai and Alhakami [19] conducted an evaluation of the accessibility of online learning platforms for users who are blind or visually impaired. The focus of this study is to understand the perception of visually impaired undergraduate students towards Blackboard's accessibility and to offer recommendations for a new Blackboard design that would meet their needs. This study uses mixed methods to assess the accessibility of Taif University's Blackboard system including automatic evaluation and user study. The recommendations presented in this research seek to make Blackboard and other educational websites created for this student more accessible. It also emphasizes how critical it is for universities to improve web accessibility for students with impairments using online learning platforms.

Alsadoon and Turkestani [20] created a questionnaire to find out the barriers faced by teachers who teach deaf students at KSU when using virtual classrooms. The aim is to identify the difficulties they face when teaching. The data was collected through unstructured 10–15-minute telephone interviews with 11 lecturers. Who taught deaf or hard of hearing students using distance learning tools such as Blackboard and Zoom during the COVID-19 pandemic. The type of questions is open-ended. One of the instructors said that when there was no interpreter. They had to communicate with their deaf students by chatting, which was very time-consuming. The others said that the technical issues prevented the deaf students from seeing the sign interpreter who was unable to translate the information given by the teacher at the same time. Some agree that most of the students do not want to appear in front of the camera. others said that asking questions took a long time in the VC. Deaf students use sign language to ask questions, which the interpreter then interprets for the teacher. It is worth mentioning that one of them said that deaf students' poor writing skills made them uncomfortable posting written questions in chat. This paper recommended that Content and information for students who are deaf or hard of hearing should be developed using images and videos with subtitles combined with sign language.

Zdravkova et al [21] examined the accessibility of learning management systems, audio, and video teleconferencing platforms. In order to ensure that everyone receives a broad education without discrimination based on disability. One of those platforms was the Blackboard. So, that was the question Is the Blackboard platform compliance with WCAG 2.1? In terms of the four impairments: motor, vision, hearing, and cognitive. The results showed that the Blackboard supports a few guidelines compared to other platforms, as in Figure 1.

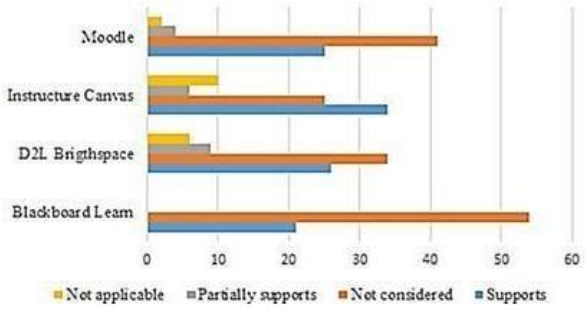

Fig 1: Evaluation Result

Beaton [22] examined the content management systems to clarify the challenges facing persons with disabilities in accessing distance learning platforms. One of those platforms was the Blackboard. Blackboard offers screen readers for both Windows and Mac platforms. Also, all navigation patterns are consistent with the most popular browsers. On the other hand, the Blackboard failed in some matters. The text on the menu is small and people with low vision would be hard-pressed to read it. In addition, there are a few icons, but they are not user-friendly. Instead of buttons, Blackboard has chosen to use highlighted text. This can be challenging for users with limited mobility.

2.3 Improving e-learning for students with disabilities

Kostandina et al [23] developed a user interface for an e-learning platform that provides a helpful and supportive environment for individuals with visual disabilities, hearing disabilities, and learning disabilities. In this paper, they determined the components of web accessibility before designing the user interface. They found users could find the required content, search, and navigate the site with ease, and they designed a site that would accommodate and help different disabilities.

Manuel R, et al. [24] proposed an abbreviation expander system for identifying abbreviations, acronyms, and their definitions based on state-of-the-art methods Natural Language Processing techniques, and a novel disambiguation method based on unsupervised learning. In the first step, the text is tokenized and then split into sentences, after which the pattern annotator is used to extract and expand abbreviations. It helps to clarify the meaning of abbreviations in an easily accessible web-based solution.

Mary Jane, et al. [25] proposed web applications empowered with assistive technology tools to teach Filipino students, especially hearing and speech-impaired students in Statistics subject. Applying an interactive and animated environment to enable a full understanding of different topics in Statistics. They focused on four modules which are Filipino sign language, speech-to-text, gamified learning, and handwritten character recognition. Each of these modules helps to understand specific topics in statistics.

Wejdan Farhan et al. [26] developed a new interactive e-learning user interface (ELUI) to engage students with hearing and visual impairments along with their colleagues in the same e-learning environment. The suggested e-learning interface's assistive features make it easier for students to use the content in accordance with their hearing and vision capabilities.

However, the findings show that all students are quite satisfied with the new interactional features in the suggested user interface.

Idor Svensson et al. [27] examine how assistive technology affects students with reading and writing disabilities. They conducted an experiment with 149 participants. During the intervention period, the intervention group received 24 sessions of assistive technology training, while the control group received standard treatment. The findings indicate that assistive technology can improve reading ability and be supportive, especially for students who have the greatest difficulties. As a result, motivation for schoolwork is also increased.

Zhu Yancong, et al [28] designed a research-based solution for facilitating classroom communication built on Kinect and embedded systematic design, and it is tailored to the communicative challenges hearing-impaired college students face in the classroom. The research applies qualitative-analysis research methods with the help of NVivo11 qualitative-analysis

Software. The authors presented findings of a study which included: sign language should be the major measure to improve classroom interaction efficiency, sign language cannot achieve a good recording function because of its transience and the accuracy of text is higher than sign language in conveying information.

Mishev, Kostadin, et al [29] developed a software module that is integrated into the e-learning platform to facilitate and make all the contents accessible to students with disabilities such as hearing and vision impairments, as well as various types of dyslexia. The newest and most efficient principles have been applied in Machine Learning for Natural Language Processing -a Deep Learning approach for text-to-speech and Macedonian sign language to guide hearing-impaired students through the content of the educational framework.

Ahmad, et al [30] developed a prototype model using AR technology to assist special needs students in learning the Quran. This proposed prototyped model is based on Augmented Reality Based Content (ARBC). It is called the mAR Qur'an and fits the needs of the development of the augmented reality environment. It has been found that this prototype model can be further developed to generate software to help hearing-impaired students memorize the Qur'an.

Bertil et al [31] proposed a MOOC platform and integrated it with the (BDC-API) architecture. It is an architecture that translates digital educational materials for the blind and deaf, thus enabling them to fully access this content. It includes some techniques such as Voice recognition and text-to-speech translation and translates into Sign language in real time. It aims to maximize the potential of MOOCs for this category and enable them to access digital educational content. By developing an easy-to-use system that can be maintained by people with no programming background knowledge. So, the proposed platform was evaluated using QEF standards based on SCORM and (ISO 9126). The standards include three areas which are educational, comfortable, and technical. The result was the proposed MOOC complied with all criteria.

Agarwal et al [32] proposed a MOOC platform for LipReading Training (LRT) for the hearing disabled using a talking head video generator, text-to-speech. They envision a MOOC platform for training humans in lipreading to potentially impact millions of people with hearing loss across the globe. The performance was tested by creating a study on 50 participants with varying degrees of hearing. The average age of the participants in this study is 35 years. All participants in this study reside in India. They show synthetic two videos which are American-accented English (AE) and Indian-accented English (IE) videos. The result shows that Synthetic videos are very helpful. The drop in performance of Real AE and Synth AE is statistically insignificant. Also, users are more comfortable lip-reading in a native accent. Table 1 shows a summary of all the reviewed literature.

Table1. Literature Review Summary

Title	Type of disabilities	Methodology
Challenges faced by Higher Education Students with Special Needs in Online Distance Learning [3]	All types	Online Survey
Students with special educational needs and assistive technologies [4]	Learning Disabilities	Literature review
Using Assistive Technology in Teaching Children with Learning Disabilities in the 21st Century [5]	Learning Disabilities	Discussed the types of AT to solve problems related to writing, reading, listening, and mathematics
Access to Assistive Technology during the COVID-19 Global Pandemic: Voices of Users and Families [6]	Not Specified	Examined the impact of COVID-19 on users of AT through interviews
Assistive Technology: Empowering Students with Learning Disabilities [7]	Reading and Writing Disabilities	Literature review
Hearing Impaired Students' Self-Efficacy on the Utilization of Assistive Technology in Federal College of Education (Special) [8]	Hearing Impaired	Investigation of the use of Assistive technology by Survey
Selection of Appropriate Technology for Children with Disabilities [9]	All Types	Investigate the importance of selecting the appropriate AT for children using a survey
Accessibility for Students with Disabilities at UAEU: An Attitudinal and Thematic Analysis [10]	All types.	Online Survey.
The Accessibility of MOOCs for Blind Learners [11]	Blind Students.	Survey.
The Use of Distance Learning and E-learning in Students with Learning Disabilities: A Review on the Effects and Some Hint of Analysis on the Use during COVID-19 Outbreak [12]	Students with learning disabilities	Literature review.
Assistive technology for the inclusion of students with disabilities: a systematic review [13]	All types.	Literature review.
Evaluating Usability for e-Learning 'Madrasati' Platform in Saudi Arabia [14]	All types	WCAG 1.0 guidelines were utilized to evaluate the Madrasti platform
Parental role and support for online learning of students with disabilities: A paradigm shift [15]	All types.	Interviews.
E-learning and the Development of L2: the Case of EFL Visually impaired Students [16]	Visually impaired Students.	The mix of both quantitative and qualitative approaches.
Designing E-Courses for Hearing Impaired Students: Practices and Challenges. ARPHA Proceedings [17]	Deaf and hearing-impaired	Designing e-courses
Use of iPads as Assistive Technology for Students with Disabilities [18]	All types	A summary of the uses of iPads as AT is needed to help the disabilities.
The Accessibility of Taif University	Blind or Visually Impaired Students	Propose several enhancements to

Blackboard for Visually Impaired Students [19]		increase the accessibility of the blackboard platform for students with visual impairments
Virtual Classrooms for Hearing-impaired Students during the COVID-19 Pandemic [20]	Deaf Students	Created a questionnaire to find out the barriers faced by teachers who teach deaf students at KSU using E-learning
Remote Education Trajectories for Learners with Special Needs During the Covid-19 Outbreak [21]	All types	Examined the compliance of learning platforms with WCAG 2.1
Distance Learning as a Levelling Tool for People with Disabilities [22]	All types	Examined the challenges facing students with disabilities in accessing distance learning platforms
User Interface for e-learning Platform for Users with Disability [23]	Visual, hearing, and learning disabilities	Developed a user interface for an e-learning platform
"Abbreviation Expander" - a Web-based System for Easy Reading of Technical Documents [24]	Reading and Writing Disabilities	Abbreviation expander system
"An Assistive Technology Using FSL, Speech Recognition, Gamification and Online Handwritten Character Recognition in Learning Statistics for Students with Hearing and Speech Impairment [25]	Hearing and Speech Impairment	Web apps equipped with AT
A comparative study of an assistive e-learning interface among students with and without visual and hearing impairments," Disability and Rehabilitation. [26]	Visual and hearing impairments	Interactive e-learning user interface (ELUI)
Effects of assistive technology for students with reading and writing disabilities. [27]	Reading and Writing Disabilities	Investigated the effects of assistive technologies on students who have difficulty reading and writing.
Designing an Interactive Communication Assistance System for Hearing-Impaired College Students Based on Gesture Recognition and Representation [28]	Hearing-impaired	Designed a research-based solution
Assistive e-Learning Software Modules to Aid Education Process of Students with Visual and Hearing Impairment: A Case Study in North [29]	Hearing and vision impairments, and dyslexia	Develop software integrated into the e-learning
Augmented reality model to aid Al-Quran memorization for hearing-impaired students [30]	Special needs	Developed a prototype using AR to learn the Quran
Assistive Technology Applied in an Inclusive MOOC for the Blind [31]	Visually impaired/blind/deaf	Develop a MOOC platform integrated with BDCAPI
Towards MOOCs for Lipreading: Using Synthetic Talking Heads to Train Humans in Lipreading at Scale [32]	Deaf	Develop a MOOC platform for Lip-reading Training

3. METHODOLOGY

In this study, the main objective is to examine the effectiveness of integrating assistive technology into the blackboard system to improve the participation process of students with visual disabilities. The followed methodology was Business Process Management lifecycle (BPM), a well-established framework that helps you identify, analyze, redesign, measure, control, and monitor business processes so that they're consistently better performing and making your organization more valuable [33]. As part of the (BPM) lifecycle, several steps are required, including process identification, process discovery, process analysis, process redesign, process implementation, and process monitoring and control. However, all of these steps are necessary to perform simulations to analyze the process and compare responsiveness. Figure 2 shows the steps.

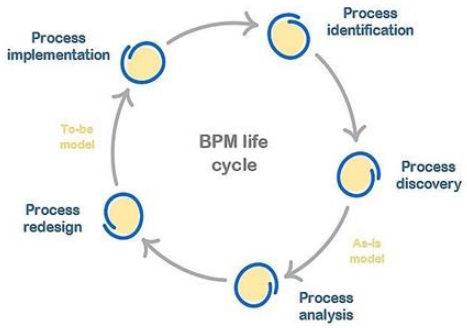

Fig 2: BPM Life Cycle

3.1 Process Identification

This section aims to describe the current business process, including all its relevant difficulties, sub-activities, functions, procedures, and stakeholders. It also provides a foundation for the following steps (i.e., process discovery, analysis, and redesign). The information for this case study was acquired from the Blackboard Ultra System. In the information collection process, the focus was on joining and participating in an online session for visually impaired students and its subtasks, duration time of each task, main roles, and stakeholders. The findings show that visually impaired students faced many challenges in using the Blackboard Ultra System including the long time and difficulty to join and participate in online sessions without assistance which affects their learning process. The main role is participation by chat and stakeholders are Students and the Blackboard Ultra System.

3.2 Process Discovery (As Is) Model

In this section, an "As-is" process was built using the Bizagi studio tool to model the current process of joining and participating in the Blackboard Ultra System. The "As-is" process means modeling the current process and clearly viewing the flows and the progress before making any changes or improvements to that process. This enables us to analyze it and suggest improvements later. Fig 3 as follows shows the

"As-is" model for the process of "joining and participating in a virtual session".

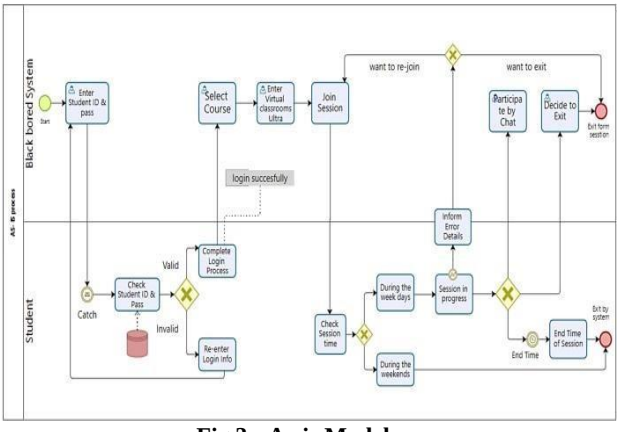

Fig 3: As-is Model

3.3 Process Analysis

This section analyzes the current "As-is" process by applying several techniques to gain insights into the issues and identify potential opportunities for redesigning the process. In this analysis stage, the techniques for evaluation are divided into qualitative and quantitative.

3.3.1 Qualitative Analysis

The value-added analysis, Issue Register analysis, and cause-effect analysis are applied to evaluate the current process.

3.3.1.1 Value-Added Analysis

In value-added analysis, the process is divided into steps, and each step is labeled with Value Added (VA) or Non-Value Added (NVA). Then in the process of redesign, all the NVA steps will be eliminated. See Table 2.

Table 2. Value-Added Analysis

Steps	Performer	Classification
Enter student ID and Password	Student	VA
Check student ID and Password	BB System	VA
Complete login process	BB System	VA
Verifying Information	BB System	VA
Select Course	Student	VA
Enter Virtual Classroom Ultra	Student	VA
Join Session	Student	VA
Session in progress	BB System	VA
Check Session Time	BB System	NVA
Participate Using Chat	Student	VA
Decide to exit	Student	VA
Re-enter login info	BB System	VA
End Time of Session	BB System	VA
Inform error details	BB System	VA
Check during weekdays	BB System	NVA
Check during weekend	BB System	NVA

3.3.1.2 Issue Register Analysis

It provides an in-depth analysis of specific issues and their quantitative and qualitative impacts. The most common issues that students may encounter when joining the Blackboard system and participating were analyzed, see Table 3

Table 3. Issue Register Analysis

Name	Explanation	Assumptions	Qualitative	Quantitative
Incorrect login information	Students enter the wrong ID or password	300 Students of King Abdelaziz University, 20% of them entered the wrong password or ID, on average 5 minutes delay to joining the session	Effect on attendance percentage on blackboard Missing some important lessons and related information	300*0.2*5 * 60 =3600 p.a
Session not created at the right time or date	Students can not join to session at a specific time	5 Sessions were created in a day, 1% of the sessions were not created at the right time or date, and on average 15 minutes waste of time until the teacher edited the session time or date	The lecture time will be reduced. As a result, it will affect the course progress.	5*1*0.01* 1 5*60 =45 p.a

3.3.1.3 Cause-Effect Analysis

A fishbone diagram was drawn to deduce the possible causes of the issues in the "as is" process as described in Fig 4. It indicates the issue of difficulty in participating and joining the sessions for visually impaired students.

3.3.2 Quantitative Analysis

The Quantitative flow analysis and simulation analysis are applied to evaluate the current processes in the quantitative part.

Fig 4: Fishbone

3.3.2.1 Quantitative Flow Analysis

Table 4 illustrates the time required for each activity in the "As-is". This will help to analyze the process's average time and compare the results with the "To-be" process during the simulation.

Table 4. Flow Analysis

Activity	Cycle time
Enter student ID and Password	1.5 mins
Check student ID and Password	1 sec
Complete login process	2 secs
Select Course	1 min
Enter Virtual Classroom Ultra	2 min
Join Session	1.5 min
Session in progress	1 sec
Check Session Time	1 sec
Participate Using Chat	3 mins
Decide to exit	30 sec
Re-enter login info	1 sec
End Time of Session	1 sec
Check during weekdays	1 sec
Check during weekend	1 sec
Inform error details	1 sec

3.3.2.2 Simulation Analysis

After the "As-is" process was modeled using the Bizagi Modeler tool, it was simulated using Bizagi Studio. The purpose is to obtain estimates that help in making appropriate decisions to improve the performance of the process. Process simulation is a popular technique for the quantitative analysis of process models. The result of this tool includes statistics of cycle times, average waiting times, and average resource

utilization. In this process model, there are no resources or waiting times, only the average time spent executing the process will be considered. Table 5 shows the simulation result.

Table 5. Simulation Result (As-is)

Name	Type	Inst. completed	Inst. started	Min. time (m)	Max. time (m)	Avg. time (m)
AS - IS	Process	1000	1000	7.58	16.15	9.01
Catch	Intermediate event	1084	1084			
Check Student ID & Pass	Task	1084	1084	0.02	0.02	0.02
ExclusiveGateway	Gateway	1084	1084			
Complete Login Process	Task	1000	1000	0.03	0.03	0.03
Re-enter Login Info	Task	84	84	0.02	0.02	0.02
Join Session	Task	1000	1000	1	1	1
End Time of Session	Task	162	162	0.02	0.02	0.02
ExclusiveGateway	Gateway	492	492			
Exit by system	End event	670				
Exit form session	End event	171				
Enter Student ID & pass	Task	1084	1084	1.5	1.5	1.5
Select Course	Task	1000	1000	1	1	1
Enter Virtual Classrooms Ultra	Task	1000	1000	1	1	1
Session in progress	Task	492	492	1	1	1
ExclusiveGateway	Gateway	0	0			
Decide to Exit	Task	171	171	0.5	0.5	0.5
Participate by Chat	Task	159	159	4.5	4.5	4.5
Inform Error Details	Task	0	0	0	0	0
Check Session time	Task	1000	1000	0.02	0.02	0.02
ExclusiveGateway	Gateway	1000	1000			
During the weekdays	Task	492	492	0.02	0.02	0.02
During the weekends	Task	508	508	0.02	0.02	0.02
Start	Start event	1000				
End time	Intermediate event	162	162			

3.4 Process redesign

Process redesign occurs after analyzing the current process and finding opportunities for improvements. The improvements aim to help visually impaired students participate in the Blackboard Ultra System easily and efficiently. Also, it increases their contribution to the online session which increases understandability and learnability. As shown in Fig 5, the suggested improvement is to attach keyboard shortcuts to the system. Through keyboard shortcuts, the visually impaired students will be included in the session with their colleagues, and they can participate as well, which increases the motivation for learning.

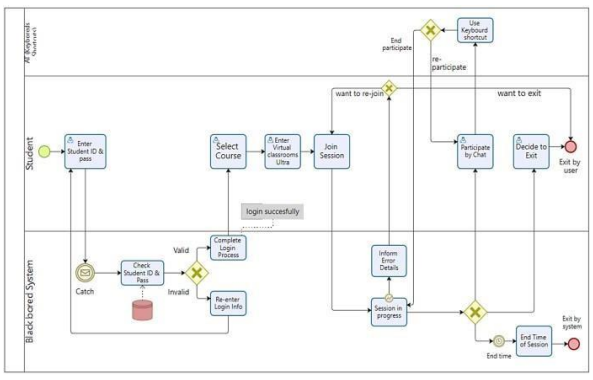

Fig 5: To be Model

3.5 Process implementation

As in the "As-is" process model, the Bizagi Studio simulation tool was used to evaluate the performance of the "To-be" process model, and Table 6 shows the results.

Table 6. Simulation Result (To-be)

Name	Type	Inst. completed	Inst. started	Min. time (m)	Max. time (m)	Avg. time (m)
Participant	Process	1000	1000	5.00	43.32	7.38
Join Session	Task	1000.00	1000	1	1	1
End Time of Session	Task	967.00	967	0.02	0.02	0.02
ExclusiveGateway	Gateway	1446	1446			
Exit by system	End event	967				
Exit by user	End event	33				
Use Keyboard shortcut	Task	897	897	0.02	0.02	0.02
Enter Student ID & pass	Task	1074	1074	1	1	1
Select Course	Task	1000	1000	1	1	1
Enter Virtual classrooms	Task	1000	1000	1	1	1
Session in progress	Task	1446	1446	1	1	1
ExclusiveGateway	Gateway	0	0			
Decide to Exit	Task	33	33	0.05	0.05	0.05
Participate by Chat	Task	897	897	2	2.00	2
Inform Error Details	Task	0	0	0	0	0
ExclusiveGateway	Gateway	897	897			
NoneStart	Start event	1000				
Check Student ID & Pass	Task	1074	1074	0.02	0.02	0.02
Complete Login Process	Task	1000	1000	0.02	0.02	0.02
Re-enter Login Info	Task	74.00	74	0.02	0.02	0.02
ExclusiveGateway	Gateway	1074	1074			
Catch	Intermediate event	1074	1074			
End time	Intermediate event	967	967			

4. RESULTS AND DISCUSSION

This research proposed a solution to facilitate and enhance the accessibility of the Blackboard Ultra System for visually impaired students by adding assistive technology. In the simulation results, the average time for the As-Is model without the use of keyboard shortcuts was 9 minutes, while the average time for the To-Be model after adding the keyboard shortcuts was 7 minutes. Also, the student's average time to participate during the default class is 4 minutes, including screen reader assistant time. With the use of keyboard shortcuts, the average time of participation becomes approximately 2 minutes.

By applying the percentage equation below [34]:

$$\text{Percentage} = {}^{(\mathcal{X}-\gamma)}/_{\mathcal{X}} * 100$$

Where:

- X: The total amount of time spent in the As-Is model.
- Y: The total amount of time spent in the To-Be model.

Compared to the As-Is model, we discovered a 22% improvement in timing which makes the learning process more effective for visually impaired students. In summary, the results show that adding the keyboard shortcuts enables visually impaired students to use Blackboard Ultra easily and allows participation during class.

5. CONCLUSION

This research aimed to improve the participation process in the Blackboard system by adding a keyboard shortcut feature to enable visually impaired students to interact effectively in virtual classrooms. The results show that keyboard shortcuts improve by 22% in this process. The research concluded that assistive technology enhances student participation in eLearning systems and increases course outcomes. Technology can motivate students with visual disabilities to participate actively in their surroundings so that they feel a sense of belonging.

5.1 Data availability statement

All data generated or analyzed during this study are included in this published article and its supplementary information files.

5.2 Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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