Designing, Development, Implementation and Assessment of the Accessible Mass Open Learning Platforms for the Visually Impaired Individuals

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ABSTRACT
The aim of this study is to design, develop, implement and evaluate an accessible mass open learning platform for visually impaired individuals. The study group consists of experts in the field who want to contribute to the study voluntarily with the snowball sampling method and have not used the platform before, with or without visual impairment. Thirty-eight visually impaired individuals and ten field experts participated in all stages of the study, a total of forty-eight volunteer users. At the analysis stage, it was tried to reach the features that an open and freely accessible learning platform should have. In this process, interviews were held with visually impaired individuals and subject matter experts. During the implementation phase, usability testing was conducted for the learning platform with visually impaired individuals. Within the scope of the usability test, the effectiveness and efficiency of the learning platform and the satisfaction levels of the participants were revealed. Visually impaired individuals were observed through the observation form for effectiveness and efficiency. In addition, semi-structured interviews were conducted with visually impaired individuals and subject area experts for satisfaction after the completion of the tasks. Content and document analysis was carried out according to the characteristics of the data obtained during the research. In the evaluation phase, the open and freely accessible learning platform developed lastly was evaluated by the automatic test tool. The design principles of the study for an accessible mass open learning platform for visually impaired individuals were revealed.
Keywords: Open and Free Learning Resource, Visually Impaired Individuals, Web Accessibility

INTRODUCTION
The ability to see, which helps to perceive and understand multiple concepts such as shape, color, motion and light (Özçetin, 2003), is very important for the individual from the moment s/he opens his/her eyes to the world. The ability to see allows the individual to first discover and know himself/herself and the environment in which s/he is located, and in the later years of one's life, to perceive and communicate with the objects, beings, events and phenomena around him/her. In other words, the individual integrates with his/her environment thanks to his/her vision.

According to World Health Organization data, while there are approximately 1.3 billion visually impaired individuals worldwide as of 2018, this number reached 2.2 billion in 2019. It is clearly seen that the number of visually impaired individuals is increasing day by day (WHO, 2019). Although the roof is used as a concept for individuals with different visual impairments, this concept is divided into two groups as blind and low vision. While blindness is used for individuals whose vision function cannot be performed by both eyes (Kelly and Clark-Bischke, 2011), it meets individuals whose vision level of both eyes is between 1/10 and 3/10.

When the literature is examined, visual impairment is defined in two different categories as legal and educational; legal definition is used in almost all fields except for the educational field. According to the legal definition, those who do not know the phenomenon of light are defined as blind, while individuals who primarily use vision despite having visual impairment appear as seeing less (Kreuzer, 2007). In the educational definition, in the Regulation on Special Education Services of the Ministry of National Education (2000), the visual disability is defined as "the negative effect on the educational performance and social adaptation of the individual due to the partial or complete inadequacy of vision". Because individuals primarily benefit from the sense of vision in their learning processes. Visually impaired individuals use their hearing and touch senses in the learning process.

Many studies show that visually impaired individuals can use their hearing and touch senses better than individuals without disabilities (Hertrich, Dietrich, Moos, Trouvain and Ackermann, 2009; Goldreich and Kanics, 2003). For example, visually impaired individuals receive help from materials such as screen reading software and Braille. Low vision individuals first benefit from their vision skills in the learning process. Unlike blind individuals, in the teaching environment, writings written with magnifying glass and large fonts are sufficient in this process (WAI 2005; Enç, 2005; Collignon, Voss, Lassonde and Lepore, 2009). As can be seen, there are differences in the learning styles of visually impaired individuals. For this reason, in order not to interrupt and support the education processes of visually impaired individuals, there is a need for some regulations, in other words, to present the education processes specific to these individuals.

There are special purpose schools established for visually impaired individuals in the world and in our country. The aim of these schools is to eliminate the problems and obstacles faced by visually impaired individuals in their education processes and to ensure that they benefit from their education processes at the highest level and acquire a profession with them. Since the 1950s, visually impaired individuals in schools within the scope of the Ministry of National Education in our country (Gündüz, 2004) continue their education day or overnight. In addition, there are special education classes within primary and secondary schools for visually impaired individuals. In this way, visually impaired students have the opportunity to receive education through inclusion with students without disabilities. Primary education curriculum is also taken as a basis in special education classes and special education schools within schools (MEB, 2008). In addition, the use of auxiliary technologies to reach the achievements in the curricula in question and to organize the education processes in a way that will provide the highest benefit to disabled individuals makes significant contributions.

Auxiliary technologies are instruments developed to solve the problems faced by individuals with any physical disability (Pettersson and Fahlstrom, 2010). When these technologies are selected according to the needs of the visually impaired individual, they can be used actively not only in the daily life of the individual but also in the educational life (Hussin, 2013). Many different systems and applications can be used within the scope of auxiliary technologies that are of such importance in the field of education. Computers, which are an indispensable part of our daily life, constitute an important basis for auxiliary technologies used for individuals with disabilities, because computers allow visually impaired individuals to easily access information while at the same time enabling them to reuse information (Emiroğlu, 2008). Thanks to the software, applications and content developed for the visually impaired within the scope of computer technologies, disabled individuals can manage their learning processes autonomously. The open educational resources in these applications offer an enriched content to support the education of disabled individuals.

Open Educational Resources are teaching, learning, and research resources that are publicly available or that have been released under an intellectual property license that allows free use or reprocessing by others. Today, the main purpose of these resources, which have turned into a platform where open and free resource philosophy and course materials are shared (Çağıltay and Göktaş, 2016), offers a deep range of potential and opportunities especially for visually impaired individuals (Okur and Demir, 2019). In other words, in terms of eliminating the problems experienced in information sharing (Taylor, 2007), open and free education resources offer equal opportunities for the education of disabled individuals. Because these resources enable individuals with disabilities to access learning opportunities wherever and whenever they want, just like individuals who do not have visual impairment.

As can be seen, it is very important to benefit from technological opportunities in eliminating the problems and difficulties faced by disabled individuals in their education processes. Undoubtedly, this situation brings along critical contributions in terms of their participation in society. Websites, which are among the technological possibilities, act as a bridge between users and institutions. Web accessibility is the preparation of the elements and content of a web page for the needs of users. Thus, it is aimed to reach the largest user audience (Şerefoğlu and Henkoğlu, 2019).

Based on the reasons stated in this study, a platform with open and free education resources has been developed for visually impaired individuals (who do not see total and see less). In the developed platform, web accessibility, which is of great importance when using on web pages for visually impaired individuals, was taken into consideration and thus, it was aimed to leave an equal effect on every student using the platform (Güven and Sözer, 2007) and to serve the concept of mass with the designed pages. The platform designed for the study was evaluated according to the findings obtained in the application and suggestions that would benefit policy makers, education leaders, academicians and subject area experts were presented. Since this developed platform was carried out within the scope of W3C standards, it was aimed that the results obtained would be a reference study in the literature.

METHOD

Research Model

In this study, design-based research method, which is one of the quantitative research methods, was preferred. Quantitative research design is a study that aims to measure events with experiments and bring them to reality in the light of events (Arıkan, 2011). Design-based research is a systematic research design carried out by the study group and the researcher to develop the design with real tasks in a cyclical way (Wang and Hannafin 2005).

Design researches are classified into two categories as Type 1 and Type 2 in line with the purpose of the study. While Type 1 is based on the design, development and evaluation steps of the product, Type 2 takes into account the model development and evaluation process (Richey and Klein, 2005). In this study, the Type 1 category was preferred because it includes many working groups as well as product design, development and evaluation steps.

Study group

There are many different study groups in the study. The study group, which was determined on a voluntary basis by the snowball sampling method, consisted of experts who had not used the platform before, had visual impairment, had no visual impairment and were experts in the subject area. Based on the research question in the snowball sampling method, the participants direct the researcher to other participants who have similar characteristics after the interview of the researcher (Yıldırım and Şimşek, 2016).

In the need analysis phase of the study, 10 visually impaired individuals and 5 subject area experts were included. In the first cycle of the application phase, six visually impaired individuals were studied for usability test. In addition, the opinions of two subject area experts were consulted for the evaluation of the platform. In other cycles, the number of participants is higher. In the second cycle, eight visually impaired individuals were studied for usability test. In the third cycle, 14 visually impaired individuals, 5 non-visually impaired individuals and 1 subject area expert were included.

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In the study, design development design stages were followed and the said stages and the actions taken within the scope of these stages are as follows;

Identification of the Problem: After defining the research problem and defining the problem, possible solutions and theoretical framework literature review were conducted.

Problem Analysis: Studies on the subject have been examined with the literature review. Needs analysis was made and the needs of visually impaired individuals were taken into consideration and in addition, subject area experts were interviewed. Thus, the purpose of the study and the characteristics of the platform to be developed were determined.

Generating Solutions: Solutions have been developed on the subject based on the interviews made during the problem analysis phase and the results obtained from the literature review.

Development: At this stage, it was first decided that the platform to be developed should include traditional mass open online courses, which are among the MOOC types. It is designed as a teacher-centered platform where information is transferred. While developing an open and free learning platform, the needs determined during the design phase were arranged in line with the characteristics of the target audience.

Directions, emphasizing connections, ground-shape contrast, font selection, writing size, plain language use, offering alternative materials, compatible with auxiliary technologies, access with keyboard and predictability of menus in cross-page transitions were taken into consideration for individuals with low vision and visually impaired in total. An accessibility menu has been developed for visually impaired individuals by integrating with the platform. The accessibility menu can be activated with the combination of "Ctrl+B" and closed with the "Esc key", allowing the menu to be used only when needed.

The accessibility menu includes keyboard navigation, voiceover, color contrast, text size, link contents, zoom, issue reporting, and reset settings. All activated buttons are designed to be disabled with the "Reset Settings" button. When the page is opened, it is arranged to be active by default with "keyboard navigation" and "open reader" options.

Both in the accessibility menu and across the page, the Web Content Accessibility Guide is designed to ensure an open navigation mechanism based on compatibility principles. Thus, the links were made detectable and

understandable. In addition, some combinations of keys were used to quickly navigate between pages. Because shortcut keys make it easier to move around the website without using a mouse.

Voiceover with the features in the accessibility menu, color contrast section, text size, link contents, zoom and Course Evaluation Exams sections, a more functional and practical content for visually impaired individuals has been tried to be designed. Apart from the sections listed in the accessibility menu, "Help, Report Problems and Reset Settings" features have been added. A help page has been created based on the principle of correct marking of the Web Content Accessibility Guide.

As a result of the analyzes, fixed menus were preferred by avoiding the drop-down menus in the design of the page. Instead of presenting the contents to users as sliders, six popular and recently added courses are shown sequentially. Links, buttons, titles on the home page are designed according to accessibility principles. Accordingly, it is possible to stop, advance, rewind, full screen and switch between segments from the keyboard of the videos on the page containing the course contents.

Considering the principle of consistency and reliability, which is one of the basic principles of web page designs, attention has been paid to use the items, buttons and menus used on the page in the same place on each page.

Content containing information equivalent to video elements has been prepared for visually impaired individuals. Adobe Reader was preferred for alternative digital documents. These equivalent contents serve the same purpose as the content in the video.

After the course was completed, the end-of-process evaluation and measurement and evaluation process were added. During the measurement and evaluation process, multiple-choice questions were prepared according to the objectives of the content; traditional objective tests, which are among the techniques used in mass open and free measurement and evaluation, were preferred. After the completion of the exam, it was ensured that the students' results were evaluated by computers and feedback was provided.

Application: In order to detect possible problems that may be encountered in the main application of the open and free learning platform and to produce solutions in advance, a pilot application was carried out. The pilot study was conducted by a volunteer participant. Improvements deemed necessary before the actual application were made in line with the data obtained.

Evaluation: It was aimed to find answers to the questions about how to improve the design process of the open and free learning platform more effectively and efficiently. Accordingly, open and free learning platform usability test results and interviews were analyzed. The places where the participants were not satisfied and seen as incomplete and the tasks that were failed and the parts where the most performance was spent were determined. The improvements were made within the scope of three cycles and the open and free education platform was given its final form used in the application.

Data Collection Process

Observation, interview and document analysis methods were used in the data collection process of the study. Accordingly, an observation form has been developed for the evaluation of the accessible open and free education platform. Throughout the observation, notes were taken using this form and the participants were recorded on video and the status and behaviors of the participants were monitored in the usability test.

In the analysis phase of the design-based research, it conducted interviews with subject area experts, software developers and visually impaired individuals. Four different interview forms were used in these interviews. Interviews were conducted with the participants for the satisfaction stage of the evaluation step. In addition, subject area experts were asked to evaluate the accessible, open and free education platform developed by considering the usability criteria.

Steinbach (2020) emphasizes that it is not possible to determine whether a website is accessible as a result of evaluation only with automated testing tools. Therefore, in the design development research of this study, observations and interviews were made in all three cycles. After the improvements ended, the platform was evaluated with the selected automated test tools. Within the scope of this study, AChechker test instrument was preferred. According to Ahmi and Mohamod (2016), these two instruments are among the most preferred web accessibility controllers in terms of accessibility and usefulness.

Validity and Reliability

Additional methods are used to control the results of the data found by the researcher about the situation or event investigated (Yıldırım and Şimşek, 2016). The use of different methods in the studies increases the validity and reliability of the data. Within the scope of this study, the actions taken to increase validity and reliability are as follows:

- In order to report the obtained data in detail (Çokluk, Yılmaz and Oğuz, 2011), the opinions of the participants were presented as direct quotations.
- During the study process, the opinions of different participants and subject area experts were consulted and various data collection tools were used.
- In addition to the literature review conducted by the researcher, the pilot application of the interview form prepared by taking the opinion of an expert was made.
- In the process of determining the tasks included in the observation form, two subject area experts were consulted, who were graduates of CIS and accessibility experts.
- In this study, different data collection methods, which are among the types of triangulation strategy, were preferred and the data were collected by observation, interview and document analysis methods.
- The researcher took an active role in the data collection process.
- Interview data were analyzed in detail and descriptions were included in the findings section.
- After the data obtained from the participants were transcribed, the opinions of the individuals participating in the study were taken and confirmed. The codes and themes obtained were also examined by other experts.
- During the evaluation process of the platform, the opinion of more than one expert was taken.
- In order to ensure data diversity, data from various sources were collected with different participants in each cycle.

Data Collection Process and Analysis

During the analysis phase of the study, the participants were first contacted by phone and stated the purpose of the study. The audio recordings obtained as a result of the interviews made on a voluntary basis were transcribed. The created transcripts have started to be read and analyzed several times. First of all, transcripts were tried to be interpreted as a whole. Then, the data were converted into codes and themes.

During the implementation phase, interviews were held with the participants in July 2021 for the first cycle, October 2021 for the second cycle and November 2021 for the third cycle. Information, observation and interview forms were applied to the volunteers, respectively. Participants were asked to give their consent for the audio recording. Then, the observation form prepared for the use of the learning platform was applied. Through the observation form, notes were taken about the interaction of the participants' learning platform. With the completion of all tasks, the interview process was started.

For the effectiveness dimension, the successful completion of the tasks requested from the participants was taken into account. The number of movements required by the person who developed the system to perform the operation in the tasks requested from the participants was determined for the efficiency dimension. An individual without visual impairment was asked to complete the same tasks and the average time spent was tried to be determined. Finally, for the satisfaction dimension, interviews were held with five visually impaired participants and two subject area experts who participated in the application. The data recorded by voice recording in the interviews were transcribed and read several times. First of all, transcripts were tried to be interpreted as a whole. Then, the data were converted into codes and themes. The themes created in the findings section are emphasized.

FINDINGS

Findings on the Design Features of an Accessible Open and Free Learning Platform for Visually Impaired Individuals

In order to reveal the design features, in the analysis phase, ten visually impaired individuals and five subject area experts were interviewed together with the literature review. As a result of the interviews, 5 themes were determined as "problems, suggestions, exam screen design, text elements, audio and video elements" (Table 1).

Table 1. Themes Related to Design Features

Themes	Codes	Participants
Recommendations	Shortcut identification	TG1, KAU1, KAU2, KAU3, KAU5
	Keyboard access	TG1, TG2, TG4, TG8, KAU1, KAU3
	Resizing the display	TG5, KAU1, KAU2, KAU3
	Error prevention	TG2, TG5, KAU1, KAU3
Exam Screen Design	Single page design	TG3, TG6, AG1, TG7, KAU4
	Voice feedback	TG7, TG8, KAU5
	Keyboard usage	TG1, TG6, TG9, KAU4
Text Items	Resizing texts	TG3, AG1, TG9
	Shape-ground contrast in texts	TG1, TG2, AG1, TG7, TG9
	Highlighting the content on the page	TG3, TG5, TG9
Audio and Video Items	Alternate content	KAU1, KAU2, KAU3
	User control	TG4, TG6, TG8, KAU2
Challenges encountered	Describe the images	TG5, TG6, KAU1, KAU2, KAU4
	Shape-ground contrast in images	TG3, AG1, TG9, K11, K13
	Suitable title	TG2, TG4, KAU1, KAU2, KAU3
	Labeling	TG4, KAU1, KAU2, KAU3, KAU5

According to the theme of the problems encountered, it has been observed that there are mostly visual elements and software problems in terms of accessibility on the existing web pages. Since no explanations were added to the images on the web pages, it was determined that the users could not access the elements such as graphics, pictures or tables added to the pages. In addition to the fact that the visual elements were not explained, it was determined that the shape and ground contrast used in the images was not taken into consideration, however, there were problems with the titling and labeling. The statements of some of the participants related to this theme are as follows:

"*Of course, pictures are used on the pages. We try to see the writings in here by enlarging and reading them. But what makes my work here difficult is the colors used. We cannot read when the same colors are used*." (AG1)

"*It is important to make the right headings. There are pages developed as direct h2, h3 starting without h1 in the pages we examined. This accessibility problem is in a software problem as well. Heads provide great convenience when navigating with the keyboard. We can make effective pages with simple solutions*. " (KAU2)

According to the theme of suggestions, it was determined that it was important to determine keyboard access and shortcuts for individuals with total visual impairment; and to resize the screen for individuals with low vision since they mostly used magnifying glass technology on their web pages. However, it has been determined that the use of voice feedback regarding the errors made by the users may be useful in order to minimize the occurrence of errors. The statements of some of the participants related to this theme are as follows:

"*Some of my friends can use mice, but I do not prefer to use mice very much. The keyboard is easier for me. On some pages, I can navigate comfortably with the keyboard, while on others I can experience difficulties*. " (TG8)

"*I use it in the screen reader. And a magnifying glass. Since some places are sufficiently large, I may not need a voice-over program*. " (TG9)

It is seen that in the online measurement and evaluation screen designs related to the exam screen design theme, each of the questions are on different pages, the use of keyboards is not allowed in the question transitions or in answering the questions, and the lack of voice feedback is among the problems encountered. It was determined that the biggest problem in the online measurement and evaluation screen design was that each exam question was included on different pages. The statements of some of the participants related to these situations are as follows:

"In *distance education exams, we took the exams with a lot of panic and experienced difficulties.* The *more problems such as page transitions and descriptions are minimized on the exam screens, the easier it will be for us*. " (TG4)

"The *most difficult point when taking the online exam was that each question was on a different page*." (TG7)

"Voiceover *on the exam screen will also help to reduce exam anxiety*." (KAU5)

It has been observed that features such as resizing texts according to the theme of text elements, shape-ground contrast and emphasizing the titles or links on the page draw attention. Some of the opinions related to this theme are as follows;

"*It is important to present the content on the page in different dimensions, or it is better when the individual can intervene in these dimensions when individual wants.* It *is a great convenience for us to be able to intervene on the page when we* want. " (TG9)

"*We can read well when there are black texts on the white page. But sometimes neon colors are used.* The *place and duration of these are important, so I think they should not be missed*. " (TG7)

It was determined that it was important to have alternative content in the theme related to audio and video elements and to allow user control in the elements. Regarding the subject in the audio and video elements, it is important to include the summary or the whole subject on the page with different options; it has been observed that it is appropriate to leave the features such as stopping, starting or fast-forwarding in the audio and video elements to the user. The statements of some of the participants related to these situations are as follows:

"The *disabled individual is looking for something, for example, that information is included in the video. However, it facilitates the process if not only that information is given by video but also as text, for example*. " (KAU2)

"*We should be able to intervene in the videos on the web page as we wish*." (TG6)

"*It can be animated on one page; it can be video. When they move constantly, we can experience distraction. That is why it is important for us to start or stop them at any time*." (TG4)

Findings on the Availability Level of an Accessible Open and Free Learning Platform for Visually Impaired Individuals

Within the scope of the second research question of the study, the usability level of the accessible open and free learning platform developed for visually impaired individuals was tested in the context of the effectiveness, efficiency and user satisfaction levels of the platform.

Findings on the level of effectiveness of the platform during the first cycle

During the application phase, evaluations were made with six visually impaired individuals, three non-visually impaired individuals and two subject area experts and the level of effectiveness was evaluated according to the success of the participants in completing 11 tasks. Accordingly, it was determined that all participants completed the task with success (100%) in 1, 2, 3, 4, 5, 6, 9, 10 of them. Task 11 had the lowest success rate with 33.3% task success rate.

Findings on the level of productivity of the platform during the first cycle

The efficiency level of the platform was evaluated according to the time spent and the number of movements while completing the tasks with the same difficulty requested from the participants; however, the average duration of the participants with and without visual impairment was compared. When calculating, only the participants who completed the task were taken into account in Tasks 7, 8 and 11. Accordingly, it was determined that the task that the visually impaired participants spent the most time on was task 9 (38.0 seconds) and the task that they spent the least time on was task 1 (2.7 seconds). Considering the number of movements of the participants during the tasks, it was determined that all the participants completed the same number of tasks as the number of steps required while performing the process.

When the average time spent by the participants with and without visual impairment while completing the task was compared, the task with the most difference was determined as 11 (36.9 seconds/6.71 seconds) while the task with the least time was determined as 9 (38 seconds/33.6 seconds).

Findings on the level of satisfaction of visually impaired individuals and experts using the platform during the first cycle

At this stage, as a result of the experiences of the participants, interviews were held with visually impaired individuals and subject matter experts, and as a result of the interviews, 3 themes were determined as "liked features, disliked features and suggestions" (Table 2).

Table 2. Themes Related to the Satisfaction Level of the Participants

Themes	Codes	Participants
Liked properties	Accessibility menu	TG10, TG11, TG12, TG13, AG2, KAU6, KAU7
	Exam screen	TG10, TG11, TG12, TG13, AG3, KAU6, KAU7
	Features of video elements	TG10, TG11, TG12, TG13, AG2, KAU6, KAU7
	Voice feedback	TG10, TG11, TG12, TG13, AG2, AG3, KAU6, KAU7
Disliked features	Labeling	TG10, KAU6, KAU7
	Opening message.	TG11, TG12, TG13, KAU6, KAU7
Recommendations	Acceskey feature	TG1, KAU6, KAU7
	Skip to content feature	TG12, KAU6, KAU7
	Readership feature	TG10, TG11, TG12, TG13, KAU6, KAU7
	Region feature	KAU6, KAU7
	Headings	KAU6, KAU7
	Certificate	TG11, KAU6, KAU7
	Changing items as buttons	TG10, TG11, TG12

It has been observed that accessibility menu, exam screen design, features assigned to videos and audio feedback draw attention regarding the liked features theme. It was determined that providing personal feedback or providing voice feedback in case of possible problems was among the favorite features of the page. These features increased the satisfaction levels of the users and their desire to stay on the page. The statements of some of the participants related to this theme are as follows:

"*The most striking feature was the accessibility menu. I think there seems to be no need for anything extra as it contains a lot of* things." (TG10)

"*When we leave it blank, giving feedback will prevent us from skipping questions or I think it is a great convenience to say when we mark it. It is one of my favorite parts. Because it is not pleasant to experience these stresses with the stress of the exam*. " (TG11)

It is seen that there are opening message and labeling problems in the theme of disliked features. Thanks to the auxiliary technologies, it was determined that the opening message was not liked because it was easily understood whether the web pages were accessible or not, and that it was not understood what these elements were because there were elements that were not labeled on the page. The statements of some of the participants related to this theme are as follows:

"*I think there was a pop-up message at the opening, as soon as the page opened, I missed it and my mind stayed there to see what he said, I could not understand what happened*." (TG11)

"*Voice-over programs did not understand what was happening in some items on the inner pages. I think it is because it looks unlabeled*." (KAU6)

Suggestions theme was created from certificate, some items being buttons, skip content, accesskey, region and reader feature codes. While all pages of the platform were designed as accessible, it was determined that a design contrary to accessibility was made due to the downloading of the certificate as an image in the certificate section at the last stage; some links on the page were perceived as buttons. At the top of the platform, it was determined that browsing the menus such as logo, search menu, member login, sign up, help and my profile in order prevented efficiency in reaching the desired content. On the developed learning platform, shortcut definitions were made for pages or items, but this information was not liked because it was presented on the help page. In addition, it was emphasized that the status of whether the reader feature is active or passive should be left to the user. Some of the related opinions are as follows;

"The *alternative content item was not a button; I think specific situations such as a link may be a button. Because I did not think it was a link*. " (TG12)

"Accesskey *is a feature that we want to have on the pages but we do not encounter very much. I think it is not necessary for the accessibility of this page, but it can be added*." (TG10)

Findings on the level of effectiveness of the platform during the second cycle

In the second cycle of the application phase, evaluations were made with eight visually impaired individuals, four non-visually impaired individuals and two subject area experts. The level of effectiveness of the platform was evaluated according to the success of the participants in completing the task. Accordingly, all participants completed the task with success (100%) in 1, 2, 3, 4, 5 and 10 of them. While the success rate for the tasks 7, 8, 9 and 11 was 87.5%, the task success rate of task 6 was found to be 75%.

Findings on the level of productivity of the platform during the second cycle

In the second cycle, the efficiency level of the learning platform was evaluated in the same way as the first cycle. Accordingly, the tasks completed by the visually impaired participants in the longest and shortest average time were determined as task 3 (66.8 seconds) and task 1 (2.3 seconds), respectively. It was determined that Tasks 1, 2, and 10 were completed jointly by 7 participants with the same number of steps as the number of steps required for the process.

When the average duration of the participants with and without visual impairment was compared, it was seen that the task with the most difference between these periods was 11 (22.0 seconds/5.2 seconds). The task with the lowest difference was task 5 (32.8 sec/28.6 sec).

Findings on the level of satisfaction of visually impaired individuals and experts using the platform during the second cycle

In order to determine the level of satisfaction, 3 themes were determined as "positive aspects, negative aspects and suggestions" in line with the data obtained from the interviews with visually impaired individuals and subject matter experts. The themes and codes created are shown in Table 3.

Table 3. Themes Related to the Satisfaction Level of the Participants

Themes	Codes	Participants
Positive aspects	Accessibility menu	AG4, TG14, TG15, TG16, TG17, AG5, AG6, KAU8
	Shortcuts to items	AG4, TG14, TG15, TG16, TG17, AG6, KAU8, KAU9
	Personalized notices	AG4, TG14, TG15, TG16, AG5
	Labeling items	TG14, TG15, TG16, TG17, KAU8, KAU9
	Exam page	TG14, TG16, TG17, TG18, KAU8, KAU9
Negative aspects	Not being uniform of the items	TG16, TG18, KAU8, KAU9
	Message screen	TG15, TG16, KAU8
Recommendations	Personalizing the exam screen	KAU8
	Identifying star elements	TG15, KAU8, KAU9
	Description of videos	KAU8, KAU9

Accessibility menu, shortcuts defined for items, personalized feedback, tagging of items and exam screen codes were determined regarding the positive aspects theme. The accessibility menu was liked by the participants as it was suitable for both the visually impaired and the visually impaired. In the first cycle, a shortcut was defined for certain items on the pages, but as a result of the improvements, the screen reader was able to read these shortcuts. It was determined that each visually impaired participant was satisfied with the voice or written feedback he received as a result of being a member or making mistakes and the identification of almost all items on the page. In the questions and options on the exam screen, the screen reader does not have any difficulties, there are feedbacks, and the participants can easily access the complete exam button and request approval. Some of the example statements related to this theme are as follows:

"*The accessibility menu was the part that I was satisfied with because I could perform many operations from one* place." (TG17)

"It is *good that the questions are on a single page. Because when we reach each question by saying forward, we lose time in the exam.* " (TG16)

In the theme of negative aspects, the elements are not uniform and the message screen codes are included. The fact that the items were not uniform was expressed by visually impaired individuals and subject matter experts. It was thought that some participants focused directly on the message writing area on the message screen, so it would be appropriate to add an explanation about this situation on the message screen. Some of the statements related to this theme are as follows:

"*Defining items differently when browsing web pages is a challenge for people who do not see them. Because according to the features of the screen reader, those items are scanned differently*. " (KAU8)

"In *addition to finding the My Messages screen difficult, it had slipped my mind in the part I had to choose*." (TG16)

In the theme of suggestions, the codes of personalizing the exam screen, defining the stars and describing the videos are included. It was determined that the voice feedback given in the process of answering the questions should be improved on the exam screen. Although the labels on the pages are liked, it is emphasized that the evaluation stars should also be made accessible. In addition, it was said that videos should be described by subject area experts, and a video should be described in order to show at least how video descriptions are within the scope of this study. The statements of some of the participants are as follows:

"*There was an unlabeled item on the course content page. I learned this by asking you. Since visually impaired people may want to evaluate this course, these star images should be presented differently. This is quite easy*." (KAU8)

"The *fact that the video content is described in the videos on the pages where it is located is a situation that motivates the visually impaired and helps them* to come to life." (KAU9)

Findings on the level of effectiveness of the platform during the third cycle

In the third cycle of the application phase, evaluations were made with 14 visually impaired individuals, five non-visually impaired individuals and one subject area expert. As in other cycles, task completion situations are discussed first in determining the effectiveness level of the platform. Accordingly, it was determined that the success of tasks 1,2,3,4,5,7,8 and 10 was 100%, and that task 9 had the lowest success rate with 86%. The tasks in which the visually impaired participants spend the least and the most average time are task 10 (3.6 seconds) and task 5 (35.5 seconds), respectively.

Findings on the level of effectiveness of the platform during the third cycle

When the average number of steps of the visually impaired participants who successfully completed the task at the stage of determining the efficiency level of the platform was examined, it was seen that Task 1 was completed with the same number of steps as the number of steps required while performing the process by the other participants except for 3 participants, and Task 2 was completed by the other participants except for 2 participants. When the average time spent by the participants with and without visual impairment while completing the tasks was compared, it was determined that task 3 was completed in a shorter time by the visually impaired participants (26.8 seconds/ 33.2 seconds).

Findings on the level of satisfaction of visually impaired individuals and experts using the platform during the third cycle

For the level of satisfaction, 3 themes were determined as "satisfaction, difficulties and suggestions" in line with the data obtained from the interviews with visually impaired individuals and subject matter experts. The themes and codes created are shown in Table 4.

Table 4. Themes Related to the Satisfaction Level of the Participants

Themes	Codes	Participants
Satisfaction	Being accessible	TG20, TG22, TG23, TG24, AG8, TG25, TG26, TG28, GT29, TG30, KAU10
	Shortcuts to navigation	TG22, TG24, TG26, TG27, TG28, TG30
	Voice guidance	TG21, TG23, TG26
	Accessibility menu	TG19, TG20, TG22, TG24, AG8, TG29, AG9
	Lack of space in the page structure	TG21, TG22, TG25
	Ease of navigation in form fields	TG22, TG23, TG24, TG26, TG30
	Video controls	TG22, TG24, TG25, TG28, TG30
	Distinguishability of connections	AG8, AG9
	Consistency of pages	TG20, TG22, TG24, AG8, TG29
	Exam page	TG20, TG21, TG22, TG25, TG26, TG27, TG30
Problems experienced	Language issue on video control buttons	TG21, TG28, TG30

Recommendations	Images used unnecessarily	TG19, TG20
	Improvement in accessibility menu	TG20, TG22, TG25
	Unread texts	AG8, AG9
	Heading	KAU10

Codes such as page accessibility, ability to navigate through shortcuts, voice guidance, accessibility menu, lack of space in the page structure, ease of navigation in form areas, video shortcut controls, distinctiveness of links, consistency of the page and exam page were determined regarding the satisfaction theme. At the end of this cycle, it can be said that the accessibility of the page is one of the most liked features by almost all participants. When the platform started to be designed according to accessibility standards, individuals with low vision and total visual impairment were taken into consideration as the target audience. Since the options in the accessibility menu consider both groups of participants, it can be said that the menu was liked and found functional by the participants. The statements of some of the participants related to this theme are as follows:

"The *accessibility of the page is very good.* I did *not have any difficulties while navigating*. " (TG22)

"*When I entered the exam, the transition of the questions, the ability to complete the exam directly, and the feedback provided were very easy. That page was very comfortable to use*." (TG25)

"*Based on the feedback you have received so far; it has made great progress and reached a successful level in terms of accessibility*." (KAU10)

Although video controls were made on the keyboard in the theme of the problems experienced, it was expressed as a difficulty encountered by the participants to voice the button in English. Therefore, it can be said that some participants have language problems. The example statements related to this theme are as follows:

"*Those voice overs were in English while the buttons were on the keyboard in the videos. It bothers me. At first, I could not understand*. " (TG28)

"While *everything was being performed in Turkish, the video player was performed in English. I ran the word "full screen" and found it. It is not much of a problem, but it can be changed*. " (TG30)

Codes such as unnecessary visual use, improvement in accessibility menu and unreadable texts were determined regarding the theme of suggestions. Unnecessary visual use is another problem in the accessibility menu. Therefore, it can be said that improvements should be made in the options of the accessibility menu. In addition, it was suggested that the sections should be written in different colors and emphasis, and that they should increase readability. The statements of some of the participants related to this theme are as follows:

"*In the accessibility menu, the screen reader does not read some places. I think they are visual.* It *can be removed in terms of being simple*. " (TG19)

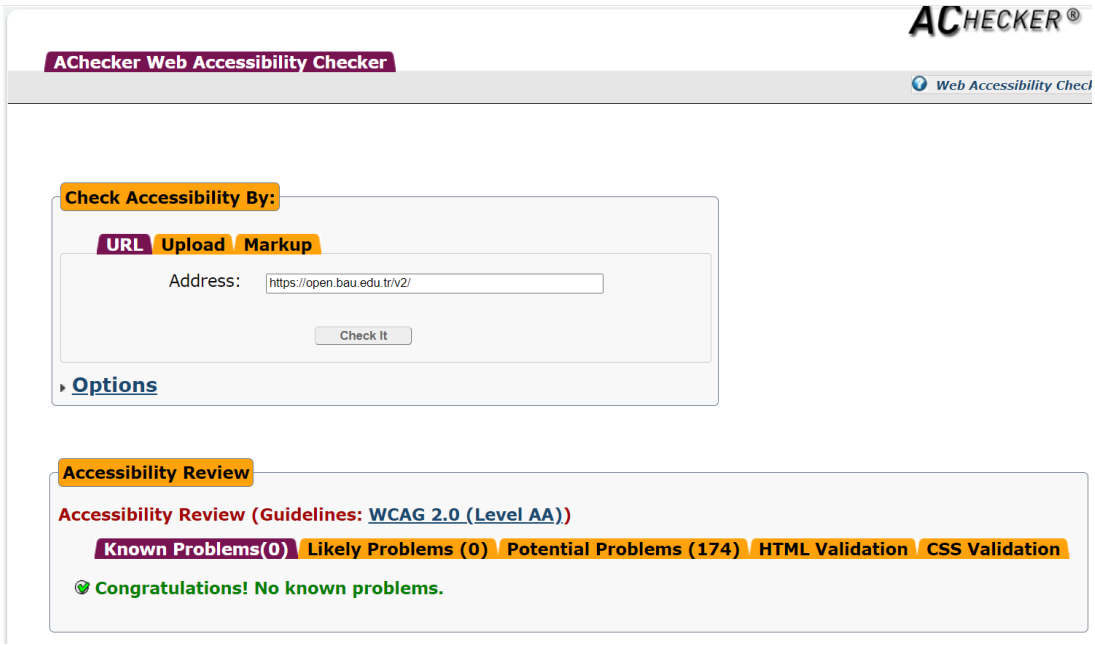
"*The fact that there are faint texts on the pages makes my job difficult because we see so little. I am having trouble finding it. Therefore, the section articles were not read for me.*" (AG8)

Findings on the results of the level of accessibility when the accessible open and free learning platform developed for visually impaired individuals is tested by the automated testing tool

Improvements were made in line with the feedback received from the participants at the end of the third cycle. Although evaluation tools are useful in the accessibility tests process, it is emphasized that user testing should definitely be done. Considering this situation, first of all, user test was performed in this study and evaluations were taken from the subject matter expert. The learning platform, which was developed as a result of the feedback received, was finally tested with an automatic evaluation tool. Thus, every error that may be encountered has been evaluated with all accessibility methods. For this study, AChecker, which is one of the web accessibility assessment tools, was selected. In addition, it was evaluated according to WCAG 2.0 Level AAA.

According to the results of the AChecker evaluation, the number of known errors was determined as zero. When looking at the potential errors, generally shape-ground contrast contrast errors were detected. Since potential errors are an error type that requires manual examination of the page, no negative feedback was received from visually impaired users about this color contrast. Therefore, necessary arrangements were made by paying attention to W3C and design principles. In addition, it can be said that the presence of different options for color in the accessibility menu minimizes this negative situation. Another problem encountered other than the color contrast is the codes written with the script. The reason for this is that the script codes cannot be changed because it is desired to make the existing page accessible. However, it was observed that the script codes shown as errors

did not pose any problems during the observation process with visually impaired individuals. One of the problems encountered as a potential problem is the lack of a sitemap on the platform. In line with the results of the automatic evaluation tools, a sitemap was created on the main page and added as a link.



As a result, the results of the automatic evaluation tool were corrected. In some warnings, user test and evaluations of the subject area expert were prioritized.

DISCUSSION AND CONCLUSION

In this study, which aims to develop an open and free accessible learning platform for visually impaired individuals (who do not see total and see less), firstly, a literature review was conducted within the scope of the design phase and the opinions of visually impaired individuals and subject matter experts were taken. According to the findings, the first design of an open and free accessible learning platform was made.

In the design process of an accessible, open and free learning platform for visually impaired individuals, six topics were focused on: text, visual, audio, video, keyboard usage and technical design principles. As a result of the interviews with the participants, the explanation of the images on the internet pages, the figure-ground contrast of the pages, the titling hierarchy, the labeling of the elements on the page, the definition of shortcuts to page transitions, keyboard access, resizing the screen, minimizing errors, audio feedback, providing alternative content and it has been concluded that the features such as leaving the page to the user's control should be included.

It has been determined that one of the most common problems in terms of accessibility on internet pages is visual elements. The reason for this is that these items cannot be read by screen readers unless explanations are added to the images on the web pages. In other words, since the visually impaired individuals can navigate the pages with the help of screen reader programs, it has been determined as the biggest difficulty to include the items on the page that do not have text equivalents. Similar results have been obtained in many studies on web accessibility (Aydın, 2011; Olive, 2009; Kurt, 2011; Emiroğlu, 2008; Chilson, 2002; Kubuş and Çağıltay, 2006; Perisa, Perakovic, & Remenar, 2012; Kaygısız, Keskin and Oğuz, 2011; Menzi and Çetin, 2015). In his study, Arık (2011) emphasizes the concept of text conjugation in images or videos so that the items on the internet pages can be accessed by screen reader programs to support this study. In other words, he focused on tagging items with the "alt" parameter in HTML codes. As can be seen, it can be said that the lack of text conjugates on accessibility is also a problem in previous studies. In addition, it has been concluded that alternative options should be offered for the content on the pages for the visually impaired individuals, and the use of the keyboard should be an alternative for page transitions or redirections. For example, it has been determined that defining specific navigation shortcuts for the internet page may provide convenience, in addition to making page transitions with the shortcuts supported by screen reader programs. In addition, the pages designed with web accessibility in mind work in harmony with screen readers. Thus, it has been seen that access to information on the site is easily provided through the shortcuts supported by the programs. For example, all links can be made easily navigable

with the letters “k” or “l” while browsing through the links. When Kurt (2011) evaluated the web pages of 10 universities in Turkey in terms of accessibility in his study, he stated that the lack of keyboard accessibility of the pages is among the striking mistakes. In addition to in-page navigation, attention should be paid to transitions between sub-pages. In addition, it was emphasized that the links on the pages work correctly. When the literature is examined, it has been observed that there are parallel problems in orientation and navigation between pages (Andronico, 2006; Menzi and Çetin, 2015; Yerlikaya and Durdu, 2020; Providenti and Zai, 2007; Aksoy and Şengel, 2018; Airplane and Çakmak, 2009). Instead of keyboard control, Kusumaningayu and Ayu (2017) developed a web access tool with talk and listen feature. In this web access tool, there are operations such as going to the web page, highlighting the information, repeating and stopping. There are different studies in the literature for web accessibility.

It has been concluded that audible feedback should be given for the problems encountered for individuals with total visual impairment. Yıldırım, Gül, Yurdagül, and Arslantaş (2016) reached a similar conclusion in their study. It has been seen that giving feedback audibly is more understandable and faster for users with total vision impairment. For individuals with total vision impairment, repeated voice-over of written feedback by screen reader programs can be considered a problem. Thus, it can be said that appropriate designs are not made for the use of the internet pages of visually impaired individuals. It has been observed that automatic completion should be allowed as well as warning notifications for errors made in the form entries on the internet pages for individuals with total visual impairment. In order to facilitate access to information, it has been determined that the title and location information of the current page should be given in a way that screen reader programs can detect. However, studies in the literature emphasize that many internet pages do not meet this requirement and cause access problems (Erkmen, Kılıç, & Holly, 2020). In line with the findings, it was concluded that alternative content should be provided to audio and video contents. In their study, Reed and Curtis (2012) emphasize the problems of visually impaired individuals in accessing digital materials and the difficulties experienced in the process of following them. For this, it can be said that it would be useful to leave the visuals such as audio or video on the web page to the user's control, but also to be presented as text. Perisa, Perakovic, and Remenar (2012), in their study, identified the lack of alternative content for videos as a major problem in terms of accessibility and reached similar results.

It has been observed that visually impaired individuals also benefit from the titles of the contents on the internet in the process of accessing information. For example, it has been determined that visually impaired individuals can navigate within the page with the help of the "h" shortcut. If proper titles are not provided on the website, it can be said that the participants have problems while browsing the page. When the literature is examined, there are many studies that give parallel results for titling (Kubuş and Çağıltay, 2006; Hassouna, Sahari, and İsmail, 2017; Yerlikaya and Durdu, 2020; Şerefoğlu and Henkoğlu, 2019). It has been concluded that for individuals with low vision, it is necessary to offer options that can interfere with screen size, color contrasts, text sizes and spaces between texts while browsing internet pages. In addition to these, it has been determined that the links and titles on the web page should be highlighted by the user at any time. He concluded that at the beginning of all the findings, attention should be paid to color and contrast for individuals with low vision, design features such as synthesized reading programs and keyboard access to pages. Individual differences (Kalac, Telli, & Erönal, 2020) should not be ignored in the universal design process. When the literature was examined, it was seen that parallel results were obtained (Dolunay & Akkan, 2019; Şerefoğlu & Henkoğlu, 2019). The reason for these results is that individuals with low vision experience great problems in the internet environment and designers still do not pay attention to these issues. It can be said that designers focus on visuals instead of thinking about universal design when designing a website. As a result of the evaluations made, it has been seen that the school website management panel, developed by Hebebci and Alan (2017), is a successful design in terms of color use. In the study conducted by Allan and Stiteley (2010), it is emphasized that interface preferences such as providing high-contrast options and adjusting the font size should be presented to the user so that individuals with low vision can use web pages easily. Michalska, You and Nicolin (2014) found similar results in their study. In this study, suggestions were made such as the use of Arial and Helvetica fonts, resizing the screen size to 200%, and a font size of 12. Arasid et al. (2018) have seen that there are many similar problems such as the use of color, media usage and structuring of page titles on web pages. Arslantürk (2021) identified the problem of insufficient color contrast in the web pages of the ministry he examined. Teymen and Özdemir (2015) concluded that the font increase feature provided for individuals with low vision on internet pages has a positive effect on increasing their reading speed. In addition to obtaining parallel results in all studies, the guidelines of the guidelines developed for internet accessibility were also developed. When the study of Yerlikaya and Durdu (2020) is examined, it is seen that the design is made with very few mistakes for individuals with low vision. Despite all these results and the design principles put forward, it is thought that the issue is ignored by the web page developers. For this reason, Durdu and Altuntaş (2020) focused on the website accessibility perceptions of

software developers in their research on Turkish software experts. As a result of the study, it was emphasized that studies should be carried out on web accessibility legislation.

In the open and freely accessible learning platform developed for visually impaired individuals, there is an online measurement and evaluation screen in addition to the course contents. After the findings obtained from the participants during the design process of these screens, the problems encountered were that the questions were not included in a single page, the keyboard was not allowed to be used in question transitions or answering the questions, and the voice feedback was not included. Tsironis, Katsanos and Xenos (2017) The most striking problem in the Udacity platform is that users have difficulties on the exam screens. It has been determined that the text boxes and radio buttons on the exam page are not accessible. When the literature is examined, it has been seen that there are accessibility problems in online measurement and evaluation screens, even in widely used learning platforms.

In the application phase, a pilot study was conducted with the visually impaired individual, and after the pilot study, the design development process was completed in three cycles. The usability level of the platform developed as a result of each cycle is discussed within the scope of effectiveness, efficiency and satisfaction levels. It was aimed to ensure that the learning platform complied with the principles of universal design and accordingly, seven principles of universal design were taken into consideration (Connell et al., 1997) with the improvements made in line with the opinions obtained as a result of the cycles.

The following results were obtained for an open and free accessible learning platform developed in the light of universal design principles: (1) Drop-down messages or drop-down menus should not be included in the platform; if there is a drop-down menu, there should be options to access the relevant section. (2) Different color contrast options should be offered in order to increase readability for individuals with low vision. (3) In order to increase readability, individuals with low vision should be given the opportunity to enlarge the texts on the page as much as they want as well as magnifying technology and to increase text gaps (5). Links should be easily emphasized on the learning platform and the contents on the page should be emphasized in different colors. (6) In order to increase the distinctiveness of the titles, individuals with low vision should be able to emphasize the titles in underlined red at any time. (7) For individuals who do not see total, all titles should be written in a certain hierarchy. (8) Explanations of the visuals on the learning platform should be added. Low vision individuals should be able to see the explanations with a single click, and all explanations should be added with the "sub" parameter for individuals who do not see total. (9) Each feature applied to the learning platform should be able to be reset with a single option. (10) Access to actively used help and message pages should be provided with different options. (11) If specific feedback is to be provided to the learning platform, a screen reader synthesized on the platform should be preferred. (12) Shortcuts should be defined for in-page and inter-page transitions. (13) Learning platform design should be consistent, simple and understandable; fixed menus should be preferred; the sitemap should be on the page. (14) Links and titles should be written appropriately according to HTML tags. (15) Both voice guidance and written warnings should be made about the problems experienced in the forms on the learning platform; written warnings should be written in red for individuals with low vision. (16) The page titles of the learning platform should be defined appropriately; users should be able to read the names of the page they are on with "Insert+F7". (17) Keyboard control should be provided for video items; when the videos are completed, they should provide voice guidance. (18) Content containing information equivalent to video elements should be prepared for visually impaired individuals; Adobe Reader should be preferred for alternative digital documents. (19) In the pages deemed necessary, the elements that the cursor will focus on should be determined. (20) The measurement and evaluation should be designed in such a way that the questions on the web pages are displayed on a single page, and the questions are read as a., b., c., while the options are read with the reader tool. (21) At the beginning and end of the exam, the routing, which can be interacted via the pop-up message and voiceover keyboard, should be submitted to the user for approval. The duration of the exam should be expressed aloud as soon as the exam starts and at certain intervals; when the user wants to know the remaining time, the user should be given feedback about the remaining time with the combination of "Ctrl+ Z". (22) When the correct answer is desired to be marked on the measurement and evaluation screen, it should be possible to mark with the "Enter" button as well as the mouse. Voice guidance should be made when the option is checked; feedback should be given when the question is left blank. (23) Region feature should be defined as the beginning of the page, the middle of the page and the end of the page in the sections on the learning platform. (24) If there is a screen reader specific to the page, it should be activated according to the user's own request. (25) The certificates to be given to the users who are successful in the course on the learning platform should be presented with a QR code.

When the learning platform, which was developed with the AChecker automatic evaluation tool in line with the design principles set out within the scope of the study, was tested, no known error was encountered. When the

literature was examined, it was seen that the web pages selected using the AChechker test tool were evaluated (Delen and Abdüsselam, 2015; Çelik, 2014; Akgül and Vatansever, 2016b; Karaim and Inal, 2017; Acosta-Vargas et al., 2018; Aksoy and Şengel, 2018; Ataç, Beyazgül and Cengiz, 2020). Unlike the open and free learning platform developed, the most common error is the lack of text explanations of the pictures. Unlike the study of Shubina (2016), it was observed that although there were technical errors on the Udacity platform, there were no technical errors on the open and free learning platform developed. Because the platform is designed with W3C standards in mind. The open and free accessible learning platform, which does not have any known mistakes, also helps visually impaired individuals to adopt an uninterrupted learning approach in their daily lives with its user-friendly interface (Kishore and Raghunath, 2015). Thus, like individuals who do not have visual impairment, individuals with visual impairment can have the opportunity to learn at any time and anywhere (Wong and Looi, 2011). In this context, one of the biggest advantages of the open and free accessible learning platform developed as a result of this study is that it is accessible and offers lifelong learning.

When the results obtained in the study are evaluated holistically, it is clearly seen that the most important issue in Web accessibility is that the software developers who design the websites should have sufficient knowledge about the concept of universal design and accessibility. For this reason, it is important for these people to be involved in educational processes that will increase their awareness about learning platforms and the accessibility of digital materials. It is thought that showing accessible design examples in practice within the scope of these training processes will be a guide for software developers.

In order for visually impaired individuals to benefit effectively from the applications developed in the field of information technologies, in other words, the needs of disabled users should be taken into consideration. The developed internet-based software should be subjected to automated test tools and user test and necessary corrections and improvements should be made in line with the opinions obtained. It is thought that the results obtained in this study also contain important feedback in the development of new designs, and it is predicted that it will make significant contributions to the desired quality of these contents by considering the design principles.

In this study, entrepreneurship course was selected as the demo course. In line with the design principles, it is thought that the research of the effectiveness and efficiency of the learning platform by preparing numerical course contents will contribute to the literature. Apart from this, the contribution of open learning platforms to lifelong learning skills in visually impaired individuals can be investigated with the studies to be carried out with different age groups; experimental studies can be conducted to investigate the effect of this platform on success; and the attitude scale regarding accessible mass open learning platforms can be developed by taking into account the themes and interview expressions obtained from the opinions of the participants.

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