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Accessibility Barriers for Blind Students in Teaching-learning Systems

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Abstract: The use of digital technology by educators has received increasingly higher focus in the recent years. In spite of this, students with disabilities still face many accessibility obstacles while using digital technologies. In this context, this paper has the main goal of identifying the accessibility barriers faced by the community of blind students and highlighting the main factors that hinder this community from accessing learning objects. For this purpose, initially, a Systematic Literature Review (SLR) was conducted, with which it was possible to collect the main accessibility problems identified by the scientific community. In order to complement and detail the information obtained in the SLR, a questionnaire was submitted to blind students, in which it was possible to discover new difficulties from a practical point of view. Finally, the accessibility barriers found in the SLR and in the questionnaire responses were analyzed and the results obtained were related to the Web Content Accessibility Guidelines (WCAG), the main document that explains how to make web content accessible for people with disabilities. This work seeks to explain the main factors that hinder or prevent access to learning objects in teaching-learning systems, promote a discussion on alternatives for improving these resources, identify gaps and guide more detailed studies on the subject.

Keywords: accessibility barriers, blind, student, systematic literature review, learning objects, teaching/learning strategies, special needs education
Categories: H.3.1, H.3.2, H.3.3, H.3.7, H.5.1
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1 Introduction

The advancement of Information and Communication Technologies has provided several initiatives to improve and stimulate the learning process [Marcolino and Barbosa, 2016, Biard et al., 2018, Fu and Hwang, 2018, Jahnke and Liebscher, 2020]. As technology is incorporated into the learning process, adaptations of educational content are necessary [Prieto et al., 2013, Al-Amri et al., 2020].

Research related to the use of technology in education has received increasing attention from scholars in recent years [Queiros et al., 2016]. An important result concerns diversity in the classroom because instructors are being challenged to teach students with a wide variety of skills and needs, valuing the process of inclusive education [Mourão and Netto, 2018, Menezes and Prikladnicki, 2018].

According to the IEEE [IEEE-LTSC, 2002], a learning object is defined as any entity, digital or otherwise, that can be used, reused or referenced for learning, education or training. Thus, considering the field of Education, one can observe the importance of using accessible learning objects for students with disabilities, in order to guarantee access to education for all.

According to previous research, the COVID-19 pandemic reinforced distance learning [Freire et al., 2020], however, several elements can be considered barriers to access for students with disabilities. Despite all the models, techniques and approaches already developed to produce accessible learning objects for the visually impaired [Soares et al., 2023], blind students still face several accessibility problems. Furthermore, basic and higher education institutions migrated to virtual environments, without carrying out an in-depth study of the technological difficulties, or even the possible low digital literacy of their students [Porte and Rocha, 2021].

Although Graphical User Interfaces are widely regarded as a major advance in human-computer interaction, their heavy reliance on visual cues for input and output presents a significant problem for students with visual impairments [Kline and Glinert, 1995, Shoemaker, 2002]. Systems aimed at the field of Education usually present some of these very visual elements, such as the intense use of images, graphs and tables. In this sense, problems with the user interface can lead to accessibility barriers which are conditions that make interaction difficult. Consequently, these barriers make it difficult for students to achieve their goal when using the web on mobile or desktop devices [Brajnik, 2008].

This work aims to identify accessibility barriers for blind students, focusing on the Education area in order to explain the main factors that hinder or prevent access to computer systems. Initially, in order to identify the main accessibility barriers in the context of this research, a Systematic Literature Review (SLR) was carried out in which it was possible to identify and categorize the main barriers. Then, to complement and detail the information obtained in the SLR, a questionnaire was submitted to blind students in which it was possible to understand more clearly the barriers and discover new difficulties. Finally, a comparison was made in order to verify what is common between SLR and the accessibility barriers highlighted by the participants and to analyze the relationship of the results obtained with WCAG 2.1.

This work is organized as follows: Section 2 presents concepts about accessibility and learning objects; Section 3 describes the planning, conduction and analyzing of data obtained in the Systematic Literature Review; Section 4 presents the results of the Systematic Literature Review; Section 5 presents the planning, data collection and results of the questionnaire; Section 6 discusses the main results of the study and their implications; Section 7 discusses the threats to validity and Section 8 presents the final considerations of the work.

2 Background

This section presents the definitions and concepts useful for understanding the contents used in this work are presented.

2.1 Accessibility

Web accessibility is a complex concept and has many components. Thus, several definitions have emerged in recent years in order to explain and detail its meaning.

According to ISO/IEC 25010 [ISO, 2011], accessibility is a sub-characteristic of usability and can be defined as "the degree to which a product or a system can be used by people who have different resources and capabilities to achieve a specific objective in a certain context of use". Furthermore, the standard defines that this requirement must be complied with when a product or system is used by people with specific disabilities to achieve their objectives effectively and efficiently.

[Petrie et al., 2015] define web accessibility as the possibility for all people, especially the disabled and the elderly, to use websites in a variety of circumstances, involving conventional and assistive technologies. For [Paciello, 2000], [Thatcher et al., 2002] and [Harper and Yesilada, 2008], the goal of web accessibility is to help people with different disabilities to identify, understand, browse pages, participate and contribute to the web.

Finally, the World Wide Web Consortium (W3C) defined accessibility as "the possibility and condition of reach, perception and understanding for the use, on equal opportunities, with safety and autonomy, of the physical environment, transport, information and communication, including information and communication systems and technologies, as well as other services and facilities" [W3C, 2014].

2.2 Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) is a non-mandatory technical guidance and refers to a set of documents that explains, through guidelines and recommendations, how to make web content accessible so that people who have disabilities can also use it [WCAG 2.1, 2018].

The WCAG document [W3C BRASIL, 2020] is structured around four guiding principles that provide the basic goals that authors should achieve to make content more accessible to users with different disabilities, and three levels of compliance [WCAG 2.1, 2018].

The principles that provide the foundation for web accessibility are the following: Perceivable, Operable, Comprehensible, and Robust. Perceivable means that information and user interface components must be available to different human senses. Operable means that users must be able to interact with the different controls and interactive elements using a mouse, keyboard or other devices. Comprehensible means that web content must be clear, written without unusual words, and web pages must operate in a predictable manner. Robust means that web content should be easy to access using a wide variety of technologies, including current and future applications and assistive technology [WCAG 2.1, 2018].

For each principle, there is a set of guidelines that provide the basic goals and objective success criteria that developers must meet in order to make web content more accessible to users with different types of disabilities.

For each guideline, testable success criteria are provided to allow WCAG to be used where requirements and compliance testing are needed, such as in the project specification, procurement, regulatory, and contractual agreements. In order to meet the needs of different groups and situations, three levels of compliance are defined, which determine the adherence of web pages to the WCAG model: A (minimal compliance), AA (removes significant barriers) and AAA (significantly improves accessibility) [WCAG 2.1, 2018].

2.3 Learning objects

Learning objects emerged with the objective of locating and reusing educational content available on the web [IEEE-LTSC, 2017] and they are gaining an increasingly significant space, since they provide the teaching-learning process with an environment more interactive, dynamic and flexible [Moreira and Conforto, 2011].

In recent years, several definitions of learning objects have emerged in order to explain and detail their meaning. According to [Kay and Knaack, 2007], learning objects are defined as "interactive web-based tools that support the learning of specific concepts, improving, amplifying and guiding students' cognitive processes". "They can contain simple elements such as text, video, be a hypertext, course, application or even an animation with audio and more complex resources (...) and are characterized by promoting the construction of knowledge through interaction" [Behar et al., 2008].

Similarly, for the [IEEE-LTSC, 2017], a learning object is any digital element, such as text, video, animation, teaching material, or a combination of these elements with an established educational purpose. Additionally, [Batanero-Ochaíta et al., 2021] consider that an accessible learning object is formed by the original learning object, its adaptations and the accessibility metadata of both the original learning object and its adaptations. For example, the video, which has visual and auditory access, would be an original learning object and its possible adaptations would be an audio description of the images for blind students or subtitles for the deaf.

3 Systematic Literature Review

The research method used was based on SLR in order to carry out a comprehensive and impartial research. To conduct the SLR, the model proposed by [Kitchenham and Charters, 2007] was used, which consists of carrying out the following activities: planning, conducting and analyzing the data obtained. The process performed is described in the next subsections.

3.1 Planning

The main sub-activities related to planning the SLR involve specifying the research questions, the search string, the search strategy, sources, and inclusion and exclusion criteria. For this SLR, the research question is as follow:

Research Question: What are the accessibility barriers that blind students find in learning objects?

To define the search string, a set of keywords from studies on learning objects and accessibility was selected and these keywords were combined with the research question.

Synonyms and variations of keywords were also established. Finally, the keywords were improved iteratively, and using Boolean operators to connect them, the search string was defined:

accessibility AND (barrier OR barriers OR guideline OR guidelines OR recommendation OR recommendations) AND (education OR "learning object" OR e-learning OR m-learning OR "mobile learning") AND ("visual impairment" OR blindness)

The search strategy included the following procedures: (i) search and collect of studies using the search string, gathered from different databases; (ii) elimination of duplicate studies; (iii) filtering publications by title, keywords and analyzing abstracts using inclusion and exclusion criteria; (iv) reading the selected articles; (v) data extraction (use of an extraction form); and (vi) synthesis of results. The source list includes journals and conference proceedings available from the following digital web libraries: IEEE Xplore[1], ACM Digital Library[2], Science Direct[3], Wiley Interscience[4] and Scopus[5]. The search string was adapted as needed, due to the constraints of each database.

For the inclusion criteria, works linked to the research question and that describe barriers related to accessibility of blind students and learning objects were considered. Exclusion criteria are related to works not accessible in electronic format, not written in English or Portuguese, not peer-reviewed (e.g. preface, book, editorial, abstract, poster, panel, lecture, workshop or demonstration), works in progress and studies not related to the subject of this SLR (accessibility, visual impairment and learning objects). 26 papers were not excluded after applying the exclusion criteria and it is noteworthy that they met the inclusion criteria and therefore were considered in this study (Appendix A).

3.2 Conducting the review

The researchers carried out searches in the digital web libraries during 10–17 September 2022. One participant is a master's student, another participant is a doctoral student and two participants are professors in the field of Computer Science. The summary of the research strategy steps can be seen in Figure 1, and will be detailed below: (i) using the search string the total of 218 works were returned. (ii) Seven duplicate works were removed. (iii) Applying the inclusion and exclusion criteria, 185 works were eliminated, leaving 26 works for data extraction. Then, 26 articles were read in full (iv) and documents were created (figure 4) to record important information (v). Appendix A presents the list of studies selected.

Figure 2 shows the number of works returned by each database, using the search string. Additionally, it shows that *Scopus* is the database that returned the most results, followed by *ACM Digital Library*, *Wiley Interscience*, *Science Direct* and *IEEE Xplore*, respectively. It is worth noting that Scopus conducts research in several relevant digital libraries [Cartaxo et al., 2018].

Figure 3 presents a summary of the exclusion criteria, informing the number of works eliminated in each criterion. According to Figure 3, most studies were excluded because they had no relationship with accessibility, visual impairment and learning

[1] http://ieeexplore.ieee.org/
[2] https://dl.acm.org/
[3] https://www.sciencedirect.com/
[4] https://onlinelibrary.wiley.com/
[5] https://www.scopus.com

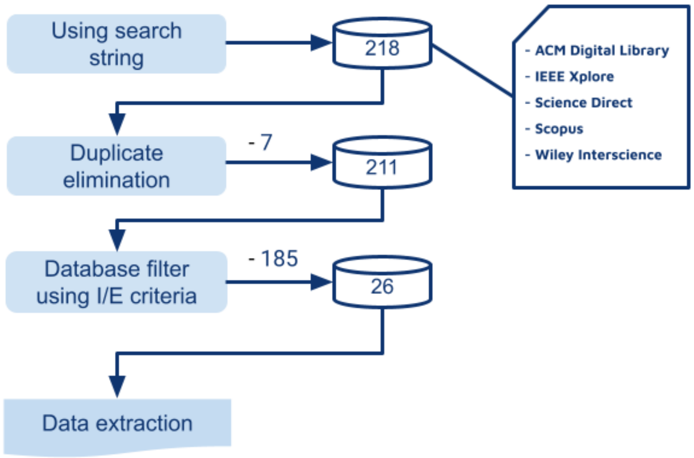

Figure 1: Summary of the research strategy steps

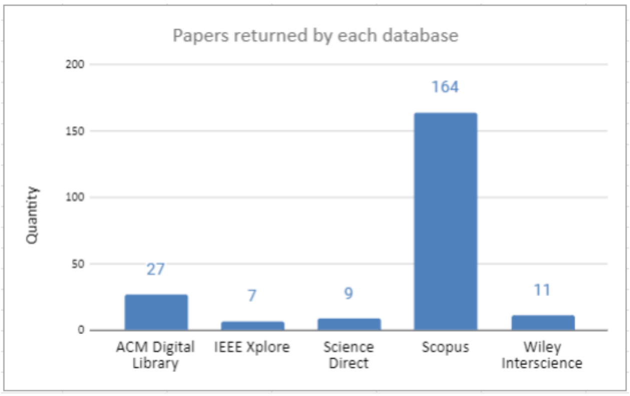

Figure 2: Number of papers

objects, followed by studies not peer-reviewed and studies not written in English or Portuguese, respectively.

The next section will present the extraction form, which was created to organize the information obtained from the papers.

3.3 Data extraction

To facilitate the extraction of data from the selected works, an extraction form was developed, as shown in Figure 4. This form is intended to assist in obtaining the necessary information to satisfy the defined research question.

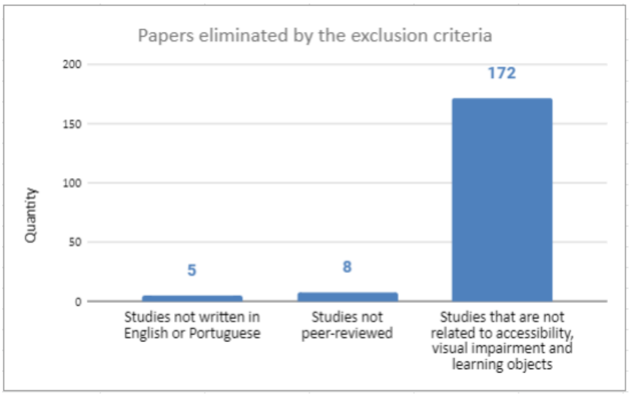

Figure 3: Summary of the exclusion criteria

Paper	
Authors	
Year	
Learning objects	
Accessibility barriers	

Figure 4: Extraction form

4 Results of the Systematic Literature Review

As described in subsection 3.2, 26 works were selected to answer the research question, as indicated below.

Research question: What are the accessibility barriers that blind students find in learning objects?

When analyzing the 26 selected studies, barriers were found in the following learning object types: course, game, graphic, image, questionnaire, table, text and video. Table 1 shows the number of papers that presented accessibility barriers for each learning object. The course, questionnaire, text and video row in this table refers to the mathematical expressions that can be found in these learning objects. The sum of the quantity column (44) is greater than the number of papers (26) because some papers addressed more than one accessibility barrier.

In the next subsections, it will be presented the main results of this SLR.

4.1 Accessibility barriers in Learning Object *Course*

Królak et al. [Appendix A, Table 6, ID 24] highlighted several difficulties faced by blind students, such as: media autostart, incorrect header structure (first-level header followed by a third-level header immediately) causing navigation problems, lack of

Learning Object	Quantity
Course	10
Image	6
Course, questionnaire, text and video	6
Questionnaire	5
Graphic	4
Table	4
Game	3
Text	3
Video	3

Table 1: Accessibility barriers for each learning object

correct language markers, and lack of notification for opening modal window. Calvo et al. [Appendix A, Table 6, ID 20] reinforced some of these barriers by pointing out pages that are updated without prompting the user and the lack of correct language markers.

Park et al. [Appendix A, Table 6, ID 07] pointed out other problems: the dynamic structure of the page provides submission feedback with animation effects that hinder the accessibility of the web content; repetitive elements on the webpage, such as course information at the top of every page, make participants spend too much time simply skimming through them and get bored easily; and screen readers read the drop-down menu (switchable function that provides users with a predefined list of items only when the mouse is rolled over) as a single button. This makes it difficult for blind students to identify that the item is a drop-down menu.

Course web pages are often full of features like pop-up ads, banners, and superfluous links. And this can disrupt navigation for blind students, as assistive technologies often cannot automatically remove these materials. In this way, assistive technologies such as screen readers are forced to simply read pop-up ads, banners and superfluous links (Chiang et al. [Appendix A, Table 6, ID 14]).

Regarding Information Technology courses, Huff et al. [Appendix A, Table 6, ID 17], Stefik et al. [Appendix A, Table 6, ID 23], Stehling et al. [Appendix A, Table 6, ID 02], Kane et al. [Appendix A, Table 6, ID 11] (apud [Albusays and Ludi, 2016]), Kearney-Volpe [Appendix A, Table 6, ID 26] (apud [Albusays and Ludi, 2019, Namdev and Maes, 2015]) highlighted the inaccessible IDEs (Integrated Development Environment) as a difficulty for blind students. Modern programming environments are quite inaccessible to the blind and visually impaired. For example, when the Job Access With Speech (JAWS) 11[6] screen reader is docked in Visual Studio 2010[7], no sound is generated when the user switches between tabs; a graphics window appears, but JAWS does not mention (Stefik et al. [Appendix A, Table 6, ID 23]).

Stefik et al. [Appendix A, Table 6, ID 23] also pointed out the difficulty in courses such as data structures, which often rely extensively on visual representations to explain concepts such as binary trees, arrays or graphs, for example. Milne et al. [Appendix A, Table 6, ID 10] highlighted the difficulty of determining the structure of the program: "When blocks were nested, as in a *for* or *if* loop, it was impossible to tell where the nesting ended and which blocks were outside".

[6] https://www.tecassistiva.com.br/catalogo/jaws/
[7] https://visualstudio.microsoft.com/

Kane et al. [Appendix A, Table 6, ID 11] (apud [Albusays and Ludi, 2016]) pointed out other problems in Information Technology courses: diagrams with no non-visual alternatives, difficulties in navigating the code using a screen reader, debugging and syntax errors (such as mismatched square brackets). Huff et al. [Appendix A, Table 6, ID 17] reinforced some of these barriers by highlighting: challenges in code navigation, for example, detecting the start and end point of functions and code blocks; trouble debugging and writing code (noting the syntax variations that programmers must follow for each language).

4.2 Accessibility barriers in Learning Object *Game*

According to Milne et al. [Appendix A, Table 6, ID 10], most games focus on visual output, such as animating avatars, and use the drag-and-drop technique to move blocks. This can be a big problem for blind students, since the animation can cause confusion and take the focus away from the main objective of the game, for example. To avoid these problems, the researchers mentioned that games should use audio output options and not focus on visual output. Also, while it is technically possible to perform the drag-and-drop technique using screen readers (for example, double-tapping and holding to perform an underlying gesture), it is necessary to provide extra information to move the blocks, such as the current location of the block and the location of the target you want to reach.

Jaramillo-Alcázar et al. [Appendix A, Table 6, ID 21] and Salvador-Ullauri et al. [Appendix A, Table 6, ID 01] pointed out difficulties such as the lack of auditory feedback and the lack of an option to turn off or hide background animations. Furthermore, Salvador-Ullauri et al. [Appendix A, Table 6, ID 01] highlighted as a barrier for the blind, games that do not allow pausing while the text is being read and the lack of text-to-speech conversion. The researchers also point out that every important piece of information needs to be reproduced audibly for the player.

4.3 Accessibility barriers in Learning Object *Graphic*

A great difficulty for blind students to understand the graphics is due to the fact that the translation of graphics to the auditory modality is not as direct as a text. Although accessibility guidelines suggest that web images should have descriptions (Nees et al. [Appendix A, Table 6, ID 08] apud [Petrie et al., 2005, W3C, 2008]), the benefits of graphics lie in their ability to communicate information about the data, such as trends or patterns (Nees et al. [Appendix A, Table 6, ID 08]).

Moreover, Huff et al. [Appendix A, Table 6, ID 17] pointed out that graphics have many visual elements that can become accessibility barriers if they are not carefully designed. Also, Stirbens et al. [Appendix A, Table 6, ID 09] and Paddison et al. [Appendix A, Table 6, ID 06] highlighted that many graphs only use colors to convey information or show relevant data.

4.4 Accessibility barriers in Learning Object *Image*

Analyzing the accessibility barriers of the image learning object, Królak et al. [Appendix A, Table 6, ID 24], Kirboyun [Appendix A, Table 6, ID 13] and Splendiani et al. [Appendix A, Table 6, ID 04] pointed out the lack of description of the images as a major obstacle for blind students. Furthermore, even when images are described, many are complex, and descriptions are not sufficient to allow understanding and interpretation (Leria et al. [Appendix A, Table 6, ID 16], Chiang et al. [Appendix A, Table 6, ID 14]).

According to the results of this SLR, it is noted that there is no consensus regarding the length of image descriptions: the widely adopted guidelines for accessibility, WCAG 2.0 [W3C, 2008], does not recommend any specific length for the *alt* attribute. According to Splendiani et al. [Appendix A, Table 6, ID 04] (apud [Clark, 2002, Korpela, 2012]) accessibility experts suggest that its length be between 50 and 1,024 characters; for Splendiani et al. [Appendix A, Table 6, ID 04] (apud [Database, 2013]), other specialists recommend keeping texts with less than 125 characters, since very popular screen readers divide the alt attribute into distinct parts of 125 characters each (excluding spaces) and read them separately as if they were separate items.

4.5 Accessibility barriers in Learning Object *Questionnaire*

Analyzing the accessibility barriers of the questionnaire learning object, Calvo et al. [Appendix A, Table 6, ID 03], Calvo et al. [Appendix A, Table 6, ID 20] and Królak et al. [Appendix A, Table 6, ID 24] highlighted the lack of descriptive texts associated with comboboxes, text boxes and buttons as a difficulty for blind students to be able to answer the questions. Also, forms can expire or update before students have time to fill them out (Stirbens et al. [Appendix A, Table 6, ID 09]).

Additionally, Leria et al. [Appendix A, Table 6, ID 16] pointed out the number of existing images in an evaluation activity based on questionnaire as a barrier, since descriptions are not always sufficient to allow understanding.

4.6 Accessibility barriers in Learning Object *Table*

Calvo et al. [Appendix A, Table 6, ID 03] and Calvo et al. [Appendix A, Table 6, ID 20] pointed out the following accessibility barriers for blind students to use tables: when using tables to build the layout of the web page, the screen reader can identify the layout as a table. This can be confusing for the user, since tables are used to structure information. Also, if the table is not well structured, the user will be lost because the screen reader cannot read merged cells or cells without text (Calvo et al. [Appendix A, Table 6, ID 03]).

Moreover, Calvo et al. [Appendix A, Table 6, ID 20] and Nees et al. [Appendix A, Table 6, ID 08] highlighted that tables with many rows make reading difficult, since the user needs to memorize the structure of the table. Similarly, Chiang et al. [Appendix A, Table 6, ID 14] cited the difficulty of navigating and interpreting tables because this learning object has a strong visual dependence.

4.7 Accessibility barriers in Learning Object *Text*

When investigating the accessibility barriers found in the texts, Calvo et al. [Appendix A, Table 6, ID 03] and Calvo et al. [Appendix A, Table 6, ID 20] highlighted that images in texts are often used to communicate information. In this sense, Race et al. [Appendix A, Table 6, ID 15] pointed out that paragraph length can be a barrier for blind students when they only want to analyze individual pieces of information: the user will need to wait for the screen reader to scroll through the entire paragraph.

4.8 Accessibility barriers in Learning Object *Video*

According to Yuksel et al. [Appendix A, Table 6, ID 19], despite international guidelines and standards, there is still a shortage of videos made available via video description for blind or visually impaired users. However, spite of the importance of details provided in the descriptions, it is noted that there is still no consensus.

Yuksel et al. [Appendix A, Table 6, ID 19] pointed out that beginner descriptors often provide a lot of detail in video descriptions, such as where words or items are on the screen or when words appear or disappear. The authors also highlighted other characteristics regarding video descriptions: the pace of the description should match the pace of the video, without leaving a huge pause in which nothing is described; and do not provide too vague details and the texts displayed on the screen must be mentioned.

Batanero et al. [Appendix A, Table 6, ID 05] state that audio descriptions should only describe details related to the concepts of the content, thus avoiding information about secondary aspects of the images, to avoid distractions and information overload. Moreover, Aydin et al. [Appendix A, Table 6, ID 22] pointed out as an obstacle the use of background music unrelated to the visual content.

Finally, while synthesized voice is generally acceptable, it can decrease clarity of descriptions when there are mispronunciations of words or when the voice does not sound natural, such as lack of spaces between sentences (Yuksel et al. [Appendix A, Table 6, ID 19]).

4.9 Accessibility barriers common to Learning Objects *course, questionnaire, text and video*

Mathematical expressions can be found in courses, questionnaire, texts or videos. The SLR has shown that there are several accessibility barriers for students to understand these mathematical expressions.

In the process of solving mathematical problems, visually impaired students are challenged in three ways: (1) how to access information that addresses the mathematical expressions can be found in courses, questionnaire, texts or videos. The SLR has shown that there are several accessibility barriers for students to understand these mathematical expressions.

In the process of solving mathematical problems, visually impaired students are challenged in three ways: (1) how to access information that addresses the mathematical problem; (2) the act of mapping information extracted from a given problem to the appropriate representation style; and (3) how to provide the obtained response in a readable form for individuals with and without vision (Alajarmeh et al. [Appendix A, Table 6, ID 18] apud [Beal and Shaw, 2008, Karshmer et al., 1999]). Therefore, reading and writing mathematical expressions are among the greatest challenges that the visually impaired face (Alajarmeh et al. [Appendix A, Table 6, ID 18]).

This process of learning mathematical content is inseparable from the ability to practice them, by solving exercises or by manually developing the sequence of logical or algebraic steps (Alajarmeh et al. [Appendix A, Table 6, ID 18]). To date, the literature has indicated that there are few efforts aimed at enabling visually impaired students to write and practice mathematics (Alajarmeh et al. [Appendix A, Table 6, ID 18]).

Among the approaches commonly used in accessibility, screen readers are considerable software tools that help the visually impaired to have access to various contents presented on the screen, that is, texts and descriptions of images or videos. However, this is not truly applicable to all types of content, especially mathematics, due to the characteristics of the subject, in addition to the fact that some mathematical contents are represented as images (Alajarmeh et al. [Appendix A, Table 6, ID 18]).

While directly translating written language into speech can make content in many subjects accessible, students in science, technology, engineering, and mathematics courses often find special cases of text (e.g., equations, mathematical formulas, charts, graphs, etc) that don't translate as readily to audio (Nees et al. [Appendix A, Table 6, ID 08] apud [Pontelli et al., 2009]). Also, there are no set standards for reading mathematical formulas. The same formulas can be read in different ways, which can cause difficulties in understanding them properly (Maćkowski et al. [Appendix A, Table 6, ID 25]). For example, Maćkowski et al. [Appendix A, Table 6, ID 25] pointed out that the understanding of formulas that contained two-dimensional nested structures (fraction in fraction) and two-dimensional mathematical structures nested with many parentheses is difficult for most students.

Furthermore, although Computer Algebra systems are indispensable tools in engineering, they are not accessible to students with visual impairments. To perform basic mathematical operations in such software becomes a challenging task, even with the aid of screen readers (Mejía et al. [Appendix A, Table 6, ID 12]). Chiang et al. [Appendix A, Table 6, ID 14] reinforced this, highlighting the difficulty of translating complex mathematical and scientific notations into computer-readable formats.

The next section will present the planning, execution and results of the Questionnaires.

5 Questionnaire

As described in 1, the research method was also based on questionnaire. It was designed with the aim of obtaining additional input from disabled users on accessibility barriers identified in the SLR. In addition, this work sought to identify new accessibility barriers experienced in practice by higher education students at public universities in Brazil. In general, an attempt was made to compare bibliographic data (obtained through the SLR) and practical experiences (obtained through the questionnaire). This allowed us to identify which barriers are most evident and identify new research opportunities that aim to propose solutions.

This section presents the planning of the questionnaire, the data collection and the results obtained with the questionnaires are presented.

5.1 Planning

Regarding the design and elaboration of the questionnaire, the questions were elaborated based on the SLR, that is, questions were created from possible gaps detected in the SLR, such as the lack of consensus on the level of detail of video descriptions or the absence of recommendations on how descriptions of images that have a lot of information should be. The questionnaire was structured in Portuguese and using the Google Forms software[8]. According to [Silva et al., 2020], Google Forms is accessible and compatible with screen readers such as JAWS[9], NVDA[10] and VoiceOver[11]. Then this questionnaire was tested by one of the authors using the NVDA screen reader in order to identify possible accessibility

[8] https://www.google.com
[9] https://www.tecassistiva.com.br/catalogo/jaws/
[10] https://www.nvaccess.org/
[11] https://www.voices.com/hire/voice-over

problems. The reading of the acronyms was the only problem detected. The screen reader pronounced acronyms, such as IDE, as a word. To resolve this issue, the meaning of the acronym was added, as follows: IDE (Integrated Development Environment).

The pilot test was carried out with two participants (P1 and P2). P1 is a Master's student in Computer Science at the Federal University of Mato Grosso do Sul and his research is related to the theme of accessibility and P2 is an employee at the Federal University of Mato Grosso do Sul who is blind. The pilot test carried out with the P1 aimed to verify if there were confusing questions or unknown terms. The test was carried out via Google Meet[12] and lasted 1 hour. P1 answered the questionnaire, informed what was not clear in some questions and made some suggestions. Then, the questionnaire was modified and sent to P2. The pilot test was carried out with P2 in order to verify the accessibility of the questionnaire and also to examine whether there were confusing questions or unfamiliar terms. The test was performed asynchronously, P2 answered all the questions in the questionnaire and did not have to ask any questions about the questions. Thus, it was verified that the questionnaire was accessible to blind students.

As result, the 25 questions (21 general and 4 about Information Technology) followed as shown in Appendix B. The questions addressed the following learning objects: course, game, graphic, image, link, questionnaire, table, text and video. The discursive questions were formulated as non-mandatory so that the participants felt free to contribute with the items that they had knowledge or desire. For example, if the participant is not used to playing games, he could leave the answer blank.

The questionnaire was sent to 109 universities through the Fala.Br[13]. Fala.Br is a brazilian government system for forwarding manifestations, such as access to information, denunciation, praise, complaint, simplify, request and suggestion. In situations where was not possible to send the questionnaire through this system, an email was sent directly to the university's accessibility department. The list of universities was obtained through the e-MEC[14], website, filtering the search by the following fields and values, respectively: search by Institution of Higher Education; administrative category: federal public and state public; academic organization: university.

5.2 Data collect

Twenty four students participated in the survey, resulting in 16 valid responses, considering the responses of the blind. The other 8 students who participated in the survey reported that they had low vision and therefore the responses were discarded from this study.

The form was available to be answered from November 1, 2022 to December 23, 2022. It is difficult to estimate the number of students who received the questionnaire, since it was sent to universities and distributed to blind students.

After obtaining the answers to the questionnaires, this work moved on to the step of separating or grouping accessibility barriers and selecting the most important information [Quiñones et al., 2018].

So, the first step was to download the files with the answers, separate them into folders, organize the answers obtained by separating the accessibility barriers considering each learning object and carry out a general reading of what was captured. Afterwards, return to the research question and the proposed objective, and then, through text clippings in

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[12] https://www.google.com

[13] https://falabr.cgu.gov.br/

[14] https://emec.mec.gov.br/

the analyzed documents, verify which themes were most repeated. Then, the synthesis of accessibility barriers obtained in the questionnaires was carried out. This result is described in Section 5.3 and was separated by accessibility barriers found in each learning object.

5.3 Questionnaire results

When analyzing the answers to the selected questionnaires, accessibility barriers were found in the following learning objects: course, game, image, questionnaire, table, text, and video. Table 2 shows the number of responses for each learning object. The course, questionnaire, text and video row in this table refers to the mathematical expressions that can be found in these learning objects.

Learning Object	Quantity
Text	16
Questionnaire	9
Table	9
Course	8
Game	8
Image	8
Technology	8
Course, questionnaire, text and video	6
Course (Information Technology)	4
Video	4

Table 2: Quantity of responses for each learning object

As done in the SLR, the accessibility barriers that blind students reported in the questionnaires will be presented.

5.3.1 Accessibility barriers in Learning Object *Course*

Participants reported difficulties that are related to any courses and also pointed out specific problems in Information Technology courses.

In general, accessibility barriers related to any course were: lack of description of images and tables; incomplete instructions for accessing available content and resources and use of a lot of visual content and absence of adapted material. Considering Information Technology courses, participants mentioned the following: IDEs have unlabeled buttons; IDEs omit information from users using screen readers and video tutorials using extremely visual language. In addition, in the case of *front-end* programming, many visual resources are used to create a user interface and it is not always possible to observe the result of the developed content.

5.3.2 Accessibility barriers in Learning Object *Game*

The answers to the questionnaires showed the following problems related to games: non-accessible design, making it impossible for blind students to use the game; lack of information such as purpose, advantages, disadvantages, risks or which intellectual capacities can be developed; lack of inclusion on the part of game creators, since many games do not take accessibility into account; visual difficulty, since almost all games require visual agility and lack of graphical interfaces accessible through screen readers.

5.3.3 Accessibility barriers in Learning Object *Image*

Students who participated in the survey reported the following image-related barriers: image without description; images with a lot of information (drawings, signs, colors...); descriptions outside of line margins; in many situations, descriptions of images made by software are not adequate; there is no consensus on the level of detail of descriptions and unfamiliar concepts presented in images. To better understand the difficulty reported in the last item, the participants cited as an example a figure that presents a giraffe. He explained that the process of mentally visualizing this type of item can be very complex, since you have to use your imagination a lot because you have never touched an animal like this.

5.3.4 Accessibility barriers in Learning Object *Questionnaire*

Participants reported the following difficulties related to the questionnaires: some platforms do not provide clear information, especially in the image descriptions; questions with image or graph without description; difficulty understanding the test to prove that the user is not a robot; question texts in image format; misplaced labels or unlabeled buttons; screen reader skipping or not reading links or highlighted words.

5.3.5 Accessibility barriers in Learning Object *Table*

Students who participated in the survey mentioned the following difficulties related to tables: screen readers read tables in different ways, for example, some associate columns with headers and others reproduce each cell individually without any type of association; tables in image format; lack of detail in row and column descriptions; inaccurate or exaggerated information; table formatting, such as merged cells or use of color as the only means of transmitting information.

5.3.6 Accessibility barriers in Learning Object *Text*

The answers to the questionnaires presented the following barriers related to the texts: text in image format; lack of description in the images that help in understanding the text; lack of well-defined titles; tutorials using visual and non-descript language; text reader applications that jump to reading a footnote without prompting; content incompatible with screen readers, for example: instead of writing 1-3, use 1 to 3, since the screen reader reads 1-3 as one three, making it difficult for the user to understand.

5.3.7 Accessibility barriers in Learning Object *Video*

Regarding the synthesized voice used in the videos, the participants reported the following problems: they do not change the tone of voice when starting or ending a sentence; pronunciation errors; speed (sometimes too slow and sometimes too fast); unhumanized voices.

5.3.8 Accessibility barriers common to Learning Objects *course, questionnaire, text and video*

The students who participated in the survey highlighted the following difficulties related to the mathematics content, which may be contained in courses, questionnaires, texts or videos: formulas presented in image format or not adapted to the screen reader; mathematical questions involving images; difficulty interpreting the parentheses.

5.3.9 Accessibility barriers related to technology

Regarding the computer, the participants highlighted the very handling of the computer, for example, moving from one application to another or finding the search provided by the computer.

Regarding the cell phone, the answers to the questionnaires pointed to the following difficulties: lack of applications to read texts; touch sensitivity on the screens, since if the user accidentally touches the screen, the system already directs him to another screen.

Regarding the learning objects, the participants highlighted that the platforms of some courses are not accessible; lay users cannot understand the platform of some courses because they present a lot of visual content or interfaces with few labels; tools to solve math questions do not have the option to copy and paste; and some programs used by Information Technology students are not completely accessible.

6 Discussion

In this section, the main results identified are discussed, verifying the intersection between the SLR and the answers to the questionnaires and analyzing the relationship between the results obtained with WCAG 2.1.

For this, a comparative study was carried out. According to [Fachin, 2001] the comparative method consists of investigating things or facts and explaining them according to their similarities and differences. It allows the analysis of concrete data and the deduction of similarities and divergences of constant, abstract and general elements, providing indirect investigations

Thus, Table 3 shows the comparison of similarities between SLR and the accessibility barriers highlighted by the participants.

As presented in Table 3, there are several accessibility barriers highlighted in the answers to the questionnaires that reinforce what has already been pointed out in the literature. With the aim of illustrating possible solutions offered by the participants when filling out the questionnaire, extracts of suggestions obtained are highlighted below:

- For the learning object *Image*, participant 7 commented that the presentation by stages can be more positive and generate better results.
- For the learning object *Game*, participants 11 and 13 commented that the game should provide a description of the space and sounds to help with movement; in addition to presenting what is happening on the screen in real time.
- For the mathematical expressions that can appear in the learning objects *course, questionnaire, text and video*, participant 13 commented that it would be interesting to pass the information of mathematical expressions written in full. For example: 2 to the power of 5 or derivative of x squared.

Learning Object	Accessibility barrier
Course	1. IDEs without accessibility 2. Courses that use a lot of visual representations
Game	1. Need for visual agility 2. Lack of accessible graphical interfaces through screen readers
Image	1. Lack of image description 2. Complex or information-intensive images 3. No consensus on the size and level of detail of image descriptions 4. Unknown concepts presented in images
Questionnaire	1. Impossibility of interpreting the question due to lack of description or insufficient description of the image or graph 2. Lack of descriptive texts associated with comboboxes, text boxes and buttons
Table	1. Table formatting 2. Difficulty navigating and interpreting tables
Text	1. Lack of description in the images that bring relevant information about the text
Video	1. Problems with the synthesized voice
Course, questionnaire, text and video	1. Mathematical content presented in image format

Table 3: Comparison of similarities between SLR and questionnaire responses

Analyzing the participants' suggestions, it is noted that very simple guidelines related to accessibility are still not implemented, despite the vast literature available. For example, the text alternative guideline from WCAG states that must be provided textual alternatives for any non-text content. Even so, it is noted that participant 11 pointed out that games should provide the description of space.

Finally, Table 4 shows the relationship of the results obtained in the questionnaires with WCAG 2.1 and Table 5 shows the relationship of the results obtained in the RSL with WCAG 2.1.

Table 4 was created by checking each accessibility barrier or possible solution presented in the questionnaires and analyzing whether there was any relationship between this barrier and accessibility guidelines for web content. For example, participants reported the following accessibility barrier: Image without description. From this barrier, this work sought to identify the instructions provided by WCAG and verify whether the problem described by the participant was associated with any principle, guideline and success criterion that is specified in the WCAG document. In the case of this example, the accessibility barrier was related to the Perceivable principle, Alternatives guideline in Text, and Content success criterion non-textual, which states that all non-text content displayed to the user must have a textual alternative. This process was carried out for the accessibility barriers found in the answers to the questionnaires and in the SLR.

It can be seen in Tables 4 and 5 that, although there are accessibility guidelines for

Questionnaire	Principle	Guideline	Success criteria	Mitigation measure
Image without description	Perceivable	Text Alternatives	Non-Text Content	All non-text content that is presented to the user has a text alternative that serves the equivalent purpose
Test to prove that the user is not a robot	Perceivable	Text Alternatives	Non-Text Content	If the purpose of non-text content is to confirm that content is being accessed by a person rather than a computer, then text alternatives that identify and describe the purpose of the non-text content are provided, and alternative forms of CAPTCHA using output modes for different types of sensory perception are provided to accommodate different disabilities.
Perform the description in the intervals of the videos, that is, when there is no speech in the video	Perceivable	Time-based Media	Audio Description (Prerecorded)	Audio description is provided for all prerecorded video content in synchronized media
Incomplete instructions for accessing available content and resources	Perceivable	Adaptable	Info and Relationships	Information, structure, and relationships conveyed through presentation can be programmatically determined or are available in text.
Text in image format	Perceivable	Distinguishable	Images of Text	If the technologies being used can achieve the visual presentation, text is used to convey information rather than images of text.
Inform where the link directs users, as well as its purpose	Operable	Navigable	Link Purpose (In Context)	The purpose of each link can be determined from the link text alone or from the link text together with its programmatically determined link context, except where the purpose of the link would be ambiguous to users in general.
Buttons without labels	Operable	Navigable	Headings and Labels	Headings and labels describe topic or purpose.
Pronunciation errors	Understandable	Readable	Pronunciation	A mechanism is available for identifying specific pronunciation of words where meaning of the words, in context, is ambiguous without knowing the pronunciation.

Table 4: List of results obtained in the questionnaires with WCAG

web content, there are still several accessibility problems in learning objects. Analyzing the results of the SLR, the responses of the participants and the comparisons made in this section, some questions can be noticed: Will the interpretation and understanding of the images used in the questionnaire learning object be the same for a blind student and for a student who is seeing the image? Would it be necessary to analyze the quantity of images and the quality of the descriptions of the images used in the tests?

Regarding games, there is a great need to create accessible games, since some participants showed that playing is almost impossible: “I don’t like to play, I believe that because of the visual difficulty, because almost all games require visual agility”, “No question of playing” or “If a game is not created for the visually impaired, it will hardly present a graphical interface accessible through screen readers”.

SLR	Principle	Guideline	Success criteria	Mitigation measure
Many charts use only colors to convey information or show relevant data	Perceivable	Distinguishable	Use of Color	Color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.
Background music unrelated to the visual content	Perceivable	Distinguishable	Low or No Background Audio	The audio does not contain background sounds and the background sounds can be turned off.
Forms can expire or update before students have time to fill them out	Operable	Enough Time	Pause, Stop, Hide	For any auto-updating information that starts automatically and is presented in parallel with other content, there is a mechanism for the user to pause, stop, or hide it or to control the frequency of the update unless the auto-updating is part of an activity where it is essential.
Games don't allow pausing while text is being read	Operable	Enough Time	Pause, Stop, Hide	For any moving, blinking or scrolling information that starts automatically, lasts more than five seconds, and is presented in parallel with other content, there is a mechanism for the user to pause, stop, or hide it unless the movement, blinking, or scrolling is part of an activity where it is essential.
Missing option to turn off or hide background animations	Operable	Seizures and Physical Reactions	Animation from Interactions	Motion animation triggered by interaction can be disabled, unless the animation is essential to the functionality or the information being conveyed.
Repetitive elements on the web page make participants spend a lot of time	Operable	Navigable	Bypass Blocks	A mechanism is available to bypass blocks of content that are repeated on multiple Web pages.
Incorrect header structure causing navigation errors	Operable	Navigable	Section Headings	Section headings are used to organize the content.
Lack of descriptive texts associated with comboboxes, text boxes and buttons	Operable	Navigable	Headings and Labels	Headings and labels describe topic or purpose.
Missing language markers	Understandable	Readable	Language of Page	The default human language of each Web page can be programmatically determined.
Pronunciation errors	Understandable	Readable	Pronunciation	A mechanism is available for identifying specific pronunciation of words where meaning of the words, in context, is ambiguous without knowing the pronunciation.
Feedback message of submit successful	Robust	Compatible	Status Messages	In content implemented using markup languages, status messages can be programmatically determined through role or properties such that they can be presented to the user by assistive technologies without receiving focus.

Table 5: List of results obtained in SLR with WCAG

As for the texts, it is necessary to be careful when using acronyms, since the screen reader reads some acronyms as words and the blind student may not understand that it is an acronym.

Finally, there are many research challenges in this area and a broad research agenda, for example: (i) integration between different areas of knowledge that could contribute to obtaining accessible learning object, such as education and computer science and (ii) elaboration of pedagogical and accessibility guidelines for learning objects.

7 Threats to validity

A. Construct validity: the construction of the questionnaire is a threat. To try to mitigate it, the questions were prepared based on the Systematic Literature Review, that is, questions were created based on possible gaps detected in the SLR. Thus, the elaboration of the questionnaire was duly considered in this study.

B. Internal validity

Threats to internal validity are:

- The different experience levels of participants with the learning objects. It was not possible to mitigate this threat, as the experience level of the participants was beyond the control of the researchers.
- The understanding and interpretation of the questionnaire questions. To mitigate this threat, conducting interviews could help users to better understand the questions and the researchers responsible for this research could ask some questions in light of the participants' responses. However, by the amount of responses obtained with the questionnaire, it is noted the difficulty of recruiting to participate in academic research.

C. External validity: the number of participants (sixteen blind students) poses a threat to external validity. This is the most difficult threat to mitigate, as the questionnaire was sent to 109 universities.

8 Conclusion

This paper presented a SLR and the submission of a questionnaire to blind students with the aim of identifying accessibility barriers in the context of education. Several accessibility problems were identified in the learning objects both in the SLR and in the questionnaire responses. In addition, the comparative study described by [Fachin, 2001] was used to analyze what there is in common between the SLR and the participants' responses and to investigate the relationship between the results obtained in the SLR and in the questionnaires with WCAG 2.1.

This work was an evolution of the previous paper [Soares et al., 2023], in which we identified, from the literature, which are the more specific models and computational techniques that exist and are used in the field of education in order to promote accessibility for the visually impaired. In this new work, we identify barriers that prevent access to learning objects in teaching-learning systems. In addition, we identified in this work that despite the similarity between the SLR and the questionnaires, the questionnaires offered a practical and detailed view of some elements that were not found in the SLR, for example, recommendations on how the descriptions of images. The questionnaires even collaborated to allow people to discuss solutions for some problems encountered and that will be part of a more complete study that is already being developed by the authors, for example, one participant highlighted that in the descriptions of the videos it is important to inform the content, the environment, image animations, movements of people and/or other living beings and the characteristics of these people. The combination of these results provides us with evidence that some research topics can be considered in order to analyze the main problems of learning objects in relation to accessibility and propose improvement alternatives. In other words, we have the scientific basis necessary to achieve a greater goal.Thus, this work sought to explain the main factors that hinder or prevent access to learning objects in teaching-learning systems, promote a discussion on alternatives for improving these resources, identify gaps and guide more detailed studies on the subject.

Regarding future work, taking into account the results obtained in this SLR and in the responses to the questionnaires, it is intended to establish a set of pedagogical and accessibility guidelines that support the process of creating learning objects, focusing on blind students in higher education. In particular, the accessibility guidelines could be grounded on WCAG success criteria raised in this paper and associated with specific implementation techniques, so that can mitigate each accessibility barrier identified. The pedagogical guidelines could be based on best practices for teaching blind students, but this subject is outside the scope of this paper. The pedagogical guidelines should be transversal to accessibility guidelines aiming to build accessible learning object by contributing to a Inclusive Education.

Conflict of Interest: the authors declare that they have no known competing financial interests or personal relationships (conflict of interest) that could have appeared to influence the work reported in this paper.

A Studies selected after full reading for data extraction

ID	Title	Year	Reference
01	A serious game accessible to people with visual impairments	2017	[Salvador-Ullauri et al., 2017]
02	Access all areas: Designing a Hands-on Robotics Course for Visually Impaired High School Students	2015	[Stehling et al., 2015]
03	Accessibility evaluation of moodle centred in visual impairements	2011	[Calvo et al., 2011]
04	Accessibility of graphics in STEM research articles: Analysis and proposals for improvement	2016	[Splendiani and Ribera, 2016]
05	Accessible platforms for e-learning: A case study	2017	[Batanero et al., 2017]
06	Applying heuristics to accessibility inspections	2004	[Paddison and Englefield, 2004]
07	Are Massive Open Online Courses (MOOCs) Really Open to Everyone?: A Study of Accessibility Evaluation from the Perspective of Universal Design for Learning	2016	[Park et al., 2016]
08	Audio assistive technology and accommodations for students with visual impairments: Potentials and problems for delivering curricula and educational assessments	2013	[Nees and Berry, 2013]
09	Barriers to distance learning in web accessibility for persons with blindness and visual impairment	2010	[Stirbens et al., 2010]
10	Blocks4All: Overcoming accessibility barriers to blocks programming for children with visual impairments	2018	[Milne and Ladner, 2018]
11	Bonk: Accessible programming for accessible audio games	2018	[Kane et al., 2018]
12	CASVI: A computer algebra system aimed at visually impaired people	2018	[Mejía et al., 2018]
13	Computer Aided System for Users with Visual Impairments	2018	[Kirboyun, 2018]
14	Computer and World Wide Web accessibility by visually disabled patients: Problems and solutions	2005	[Chiang et al., 2005]
15	Designing Educational Materials for a Blind Arduino Workshop	2020	[Race et al., 2020]
16	ENEM acessível: Autonomia para a pessoa com deficiência visual total no exame nacional do ensino médio	2018	[Leria et al., 2018]
17	Exploring the Perspectives of Teachers of the Visually Impaired Regarding Accessible K12 Computing Education	2021	[Huff et al., 2021]
18	From "reading" math to "doing" math: A new direction in non-visual math accessibility	2011	[Alajarmeh et al., 2011]
19	Human-in-the-Loop Machine Learning to Increase Video Accessibility for Visually Impaired and Blind Users	2020	[Yuksel et al., 2020]
20	Is moodle accessible for visually impaired people?	2012	[Calvo et al., 2012]
21	Mobile serious games: An accessibility assessment for people with visual impairments	2017	[Jaramillo-Alcázar and Luján-Mora, 2017]
22	Non-Visual Accessibility Assessment of Videos	2021	[Aydin et al., 2021]
23	On the design of an educational infrastructure for the blind and visually impaired in computer science	2011	[Stefik et al., 2011]
24	The Accessibility of MOOCs for Blind Learners	2017	[Królak et al., 2017]
25	Tutoring math platform accessible for visually impaired people	2018	[Maćkowski et al., 2018]
26	Web development training for students that are blind	2019	[Kearney-Volpe, 2019]

Table 6: Studies selected after full reading for data extraction

B Questionnaire

Hi! I'm Michele, a PhD student in Computer Science at the Federal University of Mato Grosso do Sul and I'm researching, together with Professor Débora Paiva, on digital accessibility for blind students in higher education. With this questionnaire, we want to identify the accessibility barriers that blind students face in higher education.

If you know other students who are studying for graduation or who have already finished higher education and are blind, I ask, kindly, send this questionnaire so that they can also collaborate with the research. The link to share this questionnaire is as follows: https://docs.google.com/forms/d/1KY9VgYvFGUX37Mjf_KbbFl2MpdzWcLFewGJyre0wgiQ

Thank you so much for your participation and contribution!

*Mandatory

If intended, enter your email:

1. You are blind?*
   ( )Yes
   ( )No

2. What is your level of education?*
   ( ) Elementary School
   ( ) High school
   ( ) Graduation (attending)
   ( ) Graduation (completed)
   ( ) Specialization
   ( ) Master's degree
   ( ) Doctorate degree

3. Do you use your computer or cell phone more to access educational content (eg videos, images and texts)?*
   ( ) Cell
   ( ) Computer

4. If intended, explain why.

5. What are the main accessibility issues you encounter when answering surveys using your computer or cell phone?

6. What difficulties do you face in understanding educational texts, such as articles, book chapters or tutorials, using a computer or cell phone?

7. What are the difficulties in understanding images with a lot of information, using the computer or cell phone?

8. What information do you expect to find in the image descriptions? In addition to information, what is the level of detail?

9. What information do you expect to find in the chart descriptions? In addition to information, what is the level of detail?

10. Some videos use synthesized voice and this voice can present some problems, such as: the synthesized voice in the video does not sound naturally, lack of spaces between words or pronunciation errors of words. Do you think there are other problems with synthesized voice? Which?

11. What information do you expect to find in the video descriptions? In addition to information, what is the level of detail?

12. What are the main information you need to interpret a table, using the computer or cell phone?

13. What are the main accessibility issues you find in the tables?

14. What are the main accessibility issues you encounter in games?

15. What are the main information you need to play a game?

16. What do you need to know about a link in order to decide whether to access it?

17. What is the best way to pass the information for you to understand the mathematical expressions?

18. What are the biggest difficulties you face to solve math questions, using the computer or cell phone?

19. What are the main accessibility problems you encounter in digital educational courses?

20. Are you studying or have a degree in Information Technology?*
( )Yes
( )No

Accessibility obstacles in the area of Information Technology

1. What are the biggest difficulties in navigating IDEs (Integrated Development Environment)? For example: Eclipse, NetBeans and Visual Studio Code.

2. What information do you need to understand block indentation in source code?

3. What are the biggest difficulties in solving syntax errors in the source code? For example, incompatible keys.

4. What are the biggest challenges related to lack of accessibility that you face in software development?

5. If you wish, you can leave new comments or information that you think is important.

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