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RESEARCH

Accessibility assessment of assistive technology for the hearing impaired

Avaliação da acessibilidade de tecnologia assistiva para surdos

Evaluación de accesibilidad de dispositivos de autoayuda para sordos

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ABSTRACT

Objective: to assess the automatic accessibility of assistive technology in online courses for the hearing impaired. **Method:** evaluation study guided by the Assessment and Maintenance step proposed in the Model of Development of Digital Educational Material. The software Assessor and Simulator for the Accessibility of Sites (ASES) was used to analyze the online course "Education on Sexual and Reproductive Health: the use of condoms" according to the accessibility standards of national and international websites. **Results:** an error report generated by the program identified, in each didactic module, one error and two warnings related to two international principles and six warnings involved with six national recommendations. The warnings relevant to hearing-impaired people were corrected, and the course was considered accessible by automatic assessment. **Conclusion:** we concluded that the pages of the course were considered, by the software used, appropriate to the standards of web accessibility.
Descriptors: People with Hearing Disabilities; Self-help Equipment; Distance Education; Internet; Digital Exclusion.

RESUMO

Objetivo: avaliar acessibilidade automática de tecnologia assistiva, na modalidade de curso *on-line,* para surdos. **Método:** estudo avaliativo, orientado pela etapa de Avaliação e Manutenção proposta no Modelo de Desenvolvimento de Material Educativo Digital. Utilizou-se *software* Avaliador e Simulador de Acessibilidade de Sítios para análise do curso *on-line* "Educação em Saúde Sexual e Reprodutiva: uso dos preservativos", conforme normas de acessibilidade de sítios eletrônicos nacionais e internacionais. **Resultados:** relatório de erros gerado pelo programa identificou, em cada módulo didático, um erro e dois avisos relacionados a dois princípios internacionais e, seis avisos envolvidos com seis recomendações nacionais. Realizou-se correção das advertências pertinentes para os surdos, sendo o curso considerado acessível pela avaliação automática. **Conclusão:** conclui-se que as páginas do curso foram consideradas, pelo *software* utilizado, adequadas aos padrões de acessibilidade na *Web*.
Descritores: Pessoas com Deficiência Auditiva; Equipamentos de Autoajuda; Educação a Distância; Internet; Exclusão Digital.

RESUMEN

Objetivo: evaluar accesibilidad automática de dispositivos de autoayuda para sordos, en modalidad de curso *online*. **Método**: estudio evaluativo, orientado por la etapa de Evaluación y Mantenimiento propuesta en el Modelo de Desarrollo de Material Educativo Digital. Se utilizó *software* Evaluador y Simulador de Accesibilidad de Sitios para análisis del curso *online* "Educación en Salud Sexual y Reproductiva: uso del preservativo", conforme normas de accesibilidad de sitios *web* nacionales e internacionales. **Resultados**: el informe de errores generado por el programa identificó en cada módulo didáctico un error y dos avisos relacionados a dos principios internacionales, y seis avisos relacionados con seis recomendaciones nacionales. Se realizó la corrección de las advertencias correspondientes para sordos, siendo el curso considerado accesible por la evaluación automática. **Conclusión**: se concluye en que las páginas del curso fueron consideradas por el *software* utilizado como adecuadas a los estándares de accesibilidad en la *Web*.
Descriptores: Personas con Deficiencia Auditiva; Dispositivos de Autoayuda; Educación a Distancia; Internet; Brecha Digital.

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INTRODUCTION

Estimates of the World Health Organization (WHO) showed that, in 2005, 278 million people in the world would have moderate to profound hearing impairment[1]. In Brazil, the estimate of people with disabilities (PwD) is approximately 46 million (23.9%), 5.10% of them with hearing impairments[2].

Hearing-impaired people have limited access to health information, which may compromise their welfare, leaving them vulnerable and prone to preventable adverse events[3]. Most professionals in this area are not proficient in sign language – system of communication using visual gestures that has its own grammatical structure[4].

Sign language is recognized as a means of communication and expression among people, allowing hearing-impaired people to achieve autonomy, as they interact with the listening society. The knowledge of health professionals about this language is crucial to an effective care[5].

Assistive technologies (AT) are defined as a set of interdisciplinary knowledge, artifacts, methods, and services that assist both daily life activities and PwD, impairments or reduced mobility, aiming to provide autonomy, independence, quality of life, and social inclusion[6]. These technologies may reduce the barrier faced by health professionals in the care of this population and often the use of this resource becomes essential for effective educational strategies.

Educational videos are an assistive technology frequently used to educate the hearing impaired. Study conducted with hearing-impaired men identified that the participants' knowledge about prostate and testicular cancer increased significantly after watching educational videos accessible to this population[7]. Similar research was conducted with hearing-impaired women with the purpose to disseminate information about cervical cancer through videos, and the results obtained were statistically similar[8]. Thus, it is possible to observe the effectiveness of the proper use of this technology in the health education of the hearing impaired.

In the context of educational technologies, the internet stands out as a support for teaching and learning processes; it reduces distances, connects people, and disseminates information of several areas of knowledge. Thus, Distance Education (DE) arises as a possibility to implement inclusion. This innovative teaching method uses the internet as a tool to spread the knowledge and enables simultaneous access to images, texts, and animations interactively through hypermedias, revolutionizing teaching methods around the world[9].

Technologies for DE teaching must meet the recommendations of usability and accessibility, removing learning obstacles, often insurmountable[10]. For DE to be attractive in the health education of hearing-impaired people, the accessibility assessment of the didactic materials used in this method becomes essential for the implementation of teaching and learning processes.

To ensure quick, easy, and efficient access to everyone, promoting social and digital inclusion of hearing-impaired people, international bodies such as the World Wide Web Consortion (W3C) proposed accessibility standard to the internet, to ensure access for everyone, regardless of the type of user, location or tool, described in the document "Web Content Accessibility Guidelines (WCAG)". The Brazilian Government adapted such recommendations to the country, designating the standards of the Electronic Government Accessibility Model (e-MAG). This document aims to create federal websites within the accessibility standards, showing how the national guidelines about accessibility on the internet can be a standard for the development of any website in Brazil focusing on all kinds of people, including hearing-impaired people[11].

Thus, the need to create an AT that helps in educational strategies for health promotion of hearing-impaired people is evident, being extremely important to verify the accessibility of such technologies to the target population. Thus, this study aims to assess the automatic accessibility of AT in online courses for hearing-impaired people.

METHOD

Ethical aspects

The creation and assessment of this technology followed resolution 466/12 and obtained approval of the National Research Ethics Commission (Conep).

Design, study location, and period

Evaluation research on the accessibility of online AT courses for hearing-impaired people about the use of condoms. We used the Model of Development of Digital Educational Material composed of five steps to create the technology, namely: Analysis and planning; Modeling (Conceptual, Navigation, Interface); Implementation, Assessment and maintenance; and Distribution[12].

In this research, we applied the assessment and maintenance step when performing software test for automatic validation of didactic modules of the course.

The AT was assessed from October to December 2014. During this period, the physical and technological infrastructure of the Laboratory of Communication in Health (LabCom_Saúde) was used, which is located in the Department of Nursing of the Federal University of Ceará (UFC).

Population or sample

The instrument assessed in the study was the course "Education on Sexual and Reproductive Health: the use of condoms", consisting of four didactic modules, namely: "Presentation", "Introduction to the Virtual Environment of Learning", "Use of Condoms", and "Review"[13]. It is noteworthy that they are in the format of video classes; the aim was to promote the students' understanding, since they use gestural communication.

Study protocol

For the automatic accessibility assessment, didactic modules were translated by a skilled professional in the area of informatics (web designer and programmer, to Hypertext Markup Language (HTML)), through which the webpages that were hosted on a private server are produced. The criteria of web accessibility, determined by the Web Content Accessibility Guidelines (WCAG), version 2.0, and by the Electronic Government Accessibility Model (e-MAG or E-GOV), version 3.0.

To complete the Model of Construction of Digital Educational Material, we proceeded to the Assessment and Maintenance, applying the Assessor and Simulator for the Accessibility of Sites (ASES) – software developed by non-governmental organization, Accessibility Brazil, in partnership with the Federal Government, which reads the HTML code of the pages requested and verifies if the creation was carried out according to the rules of international accessibility, determined by WCAG, and national, described by e-MAG. This program assess, simulates, and corrects the accessibility of websites, indicating errors and possible corrections[11].

In the report issued by ASES, errors and/or accessibility warnings infringed during the creation of the HTML pages were found, according to the rules of the WCAG and e-MAG. Errors are the differences of accessibility found that must be corrected; warnings are suggestions to improve the accessibility of webpages that do not necessarily need to be implemented.

Web accessibility guidelines described in WCAG are explained by four principles: perceivable, information and elements of the interface must be arranged so that the user notes them; operable, navigation links must be operated by the user; understandable, information and operations must be understandable; and robust, to offer robust tools and content so its interpretation is reliable for all users and assistive technologies[14].

Each principle has its corresponding guidelines, totaling 12. They inform, through 61 sub-guidelines, the actions that the authors of webpages must follow to make the content more accessible to users with different disabilities, informing the type of error infringed[14].

The Perceivable principle contains four guidelines (Texts alternatives, Time-based media, Adaptable, and Discernible) with their respective 22 sub-guidelines. The Operable principle has four guidelines (Accessible by keyboard, Enough time, Seizures, Browsable) with 20 sub-guidelines. The Understandable principle has three guidelines (Readable, Predictable, and Input Assistance) with 17 sub-guidelines, and the Robust principle contains one guideline (Compatible) with two sub-guidelines[14].

E-MAG consists of 45 recommendations for the creation of accessible websites, which are divided into six sections, namely: Marking (recommendation from 1 to 9), Behavior (recommendation from 10 to 15), Content/Information (recommendation from 16 to 27), Presentation/Design (recommendation 28 to 32), Multimedia (recommendation 33 to 37), and Form (recommendation 38 to 45)[11].

Results analysis and statistics

Through the error report provided by ASES, we analyzed the results in a descriptive and comparative way according to the accessibility criteria established by WCAG and e-MAG, which were compiled into boxes for better understanding.

RESULTS

Box 1 shows the errors and the observations of accessibility of the course pages, according to the WCAG, issued by ASES. Thus, the following topics were created: Didactic module; Type of occurrence, if error or just warning; Principle; Guideline; Sub-guideline; and Number of times.

Box 2 shows the criteria established by e-MAG and is divided into the topics Didactic module, Type of occurrence, Section, Recommendation, and Number of occurrences.

The error report was assessed along with the web designer to correct faults considered relevant. Thus, the error related to the violation of the Understandable principle and the recommendation warning no. 13 were considered relevant to the target population of the study, being adopted to obtain the final pages of the course.

Box 1 – Report of the Web Content Accessibility Guidelines issued by the Assessor and Simulator for the Accessibility of Sites, Fortaleza, Ceará, Brazil, 2015

Didactic module	Type of occurrence	Principle	Guideline	Sub-guideline	Nº of times
Classes 1 to 4	Warning	Operable	Browsable	To ignore repeated blocks of content	8
	Error	Understandable	Readable	Page language can be set programmatically	4

Box 2 – Report of the Web Content Accessibility Guidelines (e-MAG) issued by the Assessor and Simulator for the Accessibility of Sites (ASES), Fortaleza, Ceará, Brazil, 2015

Didactic module	Type of occurrence	Section	Recommendation		Nº of times
			Nº	Content	
Classes 1 to 4	Warnings	Marking	2	To organize the HTML code	4
			6	To provide anchors to go to the content block	4
			9	Not to open new instances without the user's request	4
		Behavior	11	Not to use automatic page redirection	4
				To provide alternative to change time limit	4

DISCUSSION

To create the AT systematically, the development of the online course was based on the Model of Development of Digital Educational Material. The steps encompassed the theme choice, target population, application site, creation of content and media, transfer of material to the computer, and assessment of inconsistencies in the texts, images, and media[12].

As the target population for the course was composed of hearing-impaired people, we assessed thoroughly each step of the model and added peculiar aspects of this population in the use of digital materials, in addition to performing the automatic accessibility assessment.

On the web, the aim of the tools used as assistive technologies for hearing-impaired people is to extinguish the barriers to information access available in audio, using subtitles or sign language translation[15]. Captions can help the understanding and fluency of hearing-impaired people who have no skill with sign language; however, it is not enough for the majority of this population. Hearing-impaired people whose first language is the sign language report that, even if they are proficient in Portuguese language, depending on the size of the text, they may have difficulty in reading and interpretating the information[16].

DE has different information supports and uses several means of communication, which allows the learning to be controlled by the student, not the teacher. However, due to the language barrier that virtual environments have, the autonomy of hearing-impaired people is limited, so they resort to the assistance of third parties to interpret the text in sign language and to the dictionary to know the meaning of unfamiliar words, which can generate doubts and frustrations[17].

To implement the DE teaching mode for hearing-impaired people, the creation of materials that teach the use of active methodologies and resources to support learning is required. It is essential for didactic materials to be in an accessible format to the target population. Therefore, the course created used these characteristics to promote the health of hearing-impaired people, being necessary to assess the applicability of accessible resources.

Current accessibility standards of WCAG are available in version 2.0 and the length of its guidelines on usability and navigability benefits the web content for people of different sensory, linguistic, and motor conditions[14]. For this reason, during the creation of online materials, it is essential that developers of webpages respect such recommendations.

The WCAG principles mentioned in the ASES report in the pages of the course were: Operable and Understandable. In the Operable principle, the error report issued by ASES identified two warnings in each didactic module, related to the sub-guideline To Ignore Blocks contained in the guideline Browsable. The occurrence identified demonstrates that the course was accessible regarding this aspect, since no errors were found.

The Operable principle is related to strategies adopted to facilitate user navigation. In this sense, the pages of the course were identified in simple and straightforward Portuguese, images were inserted to help the participants find the contents.

For the learning provided by the online course to work, the use of resources that facilitate the students' navigability on the pages of the course is essential. For hearing-impaired users it is necessary to employ communication tools that meet the specific needs of this population, which have different characteristics. This is an arduous task, given that site developers in general are unaware of the hearing-impaired culture and the guidelines do not consider aspects that are perceived in the presence of hearing-impaired people[18].

Communication resources, such as images, animation, and different colors are essential in the learning of hearing-impaired people. Materials developed for educational purposes must have a plain language, with lower reading level, and transmit accurate information. Thus, illustrations may corroborate with those requirements, given that they clarify the written text. In addition, the images must catch the reader's attention and interest in the material with acceptance of the population in different levels of schooling[19].

Recommendations and guidelines available to guide the development of accessible websites are insufficient to promote digital inclusion of hearing-impaired people, since the solution given to insert these people in the virtual environment suggests caption for videos that have audio and flashing error messages. However, the accessibility for hearing-impaired people does not denote only this, but mainly the translation of pages and internet content into sign language[16].

Research conducted through subjective assessment with hearing-impaired individuals, in the Modular Object-Oriented Dynamic Learning Environment (Moodle), found media and Portuguese texts without translation into sign language, demonstrating the need to change the environment of the hearing society. In addition, we identified the need for changes in the organization of the elements of the environment's design to make it clear and concise[20].

The Understandable principle identified an error in the sub-guideline Language of the Page. Thus, adjustments were made in the HTML code of the pages to insert the language used. Such a change is essential for hearing-impaired people, since the linguistic limitations presented by this population can be confusing if the page is not in a language of their knowledge. On the other hand, for those who do not understand the written text, this modification would not be needed.

A software that converts textual representations into a video in sign language is available; however, its assessment by people with ability in the language is essential, because the quality of the automatic translation, performed by software, is not comparable with the human translation[21].

Regarding the e-MAG recommendations, the error report issued by the ASES did not indicate accessibility error. It indicated, however, suggestions through warnings, related to the Marking sessions, which describes the organization of the elements of webpages, to better understanding of the user, and Behavior, which directs actions that contribute to the performance of the HTML pages. Thus, the warnings were more distinct in the recommendations 2, 6, 9, 11, and 13 of the e-MAG.

E-MAG recommendation no. 2 discusses the HTML code, which must be carried out logically and semantically. We observed the relationship with the Operable principle of WCAG,

which defines content navigation structures. The action brings benefits to all people with or without disabilities; however, the greater contribution occurs for blind people[11].

For them, the understanding of the internet content occurs through screen readers, which turn the text into sound, since webpages are predominantly visual. However, these devices have limitations that often hinder the understanding of the user about the content available on the site. For example, screen readers read the page linearly and sequentially; therefore, when the information is disorganized, it becomes confusing to blind users, considering that it might occur distortion or omission of content[22].

However, for hearing-impaired people, the organization of HTML codes does not influence their perception of the components of the page, as they possess the sense of sight and do not use proper codes to read the page, such as screen readers. We emphasize that the information contained in the page must be translated into its dominant language, sign language.

Recommendation no. 6 suggests improvement related to the creation and allocation of links in strategic places, to facilitate the viewing and help users find the content they want[11]. Therefore, this recommendation does not apply because each lesson of the course corresponds to a video, i.e., in each HTML page prepared there were only two elements: title of the lesson and video. Facing the limited number of information in the course's pages, we noted that the emphasis on any link was dispensable, since the content of the lesson can be easily accessed by clicking on the video, the only link of the page.

However, in webpages with a lot of information, the compliance of the recommendation no. 6 of the e-MAG brings promptness during navigation. However, for hearing-impaired people, the main barrier identified regarding webpage links concerns the language used, which is usually in text format. A comparative study identified greater agility in navigation by hearing-impaired people when the links were arranged through representative images of the text[23].

Recommendation no. 9 is related to avoiding the opening of new instances, such as tabs or windows, without the user's request[11]. This warning appears in the opening of the video immediately by clicking on the class, without the request of the student; however, it does not impact the accessibility of the target population, because it is understood that, when accessing the module, the student will watch the video. In addition, a feature that adjusts the exposure time of the class was attributed to the videos of the classes, according to the needs of the student; to interrupt it, just a click on the pause icon is necessary.

The indications of the Behavior session aim to promote autonomy for users that navigate the internet; thus, they contain instructions to organize the elements of the pages[11].

Research warns that strategies that aim at teaching, such as the online course assessed in this study, must be based on strategies that promote self-determination, i.e., to empower individuals to make their own choices, according to their values, preferences, and abilities. To implement these features enables more pleasure in activities[24].

Recommendation no. 11 cautions that the pages should not have auto update features, as they may confuse blind people, especially the ones who use screen readers to navigate the internet. The automatic update of the pages of the course does not impact the accessibility, considering that the content on the page is static; the presence of this feature is indifferent in the navigation of the user. Thus, there is no need for adjustment regarding this recommendation.

The recommendation no. 13 explains that the videos must include a tool that allows the modification of the time limit, being extremely pertinent and relevant to the target population of the study. The error report of ASES did not show the noncompliance of this standard as a mistake, because there are situations in which a time limit must be imposed[11].

To control the speed adjustment, to pause, and to stop were the solutions indicated by research that aimed to assess basic elements in websites to meet the requirements and needs for inclusion of hearing-impaired people in the digital world[16].

The existing web accessibility standards are insufficient to meet the specific needs of hearing-impaired people who use sign language as their first language, since, although the online course assessed uses sign language to expose its content, in the description of the guidelines and recommendations analyzed, this essential peculiarity is not required to the hearing-impaired community.

Thus, hearing-impaired culture and the linguistic structure of this user profile must be understood, as well as the different levels of hearing impairing and its specificities, so as not to standardize hearing impairment as just the lack of hearing[25].

Currently, accessibility-related issues gain prominence in society, in which various areas of knowledge come together to promote the inclusion of PwD. In the Information Science field, digital environments should be based on the needs of users, allowing for accessibility of different people, regardless of their sensory, linguists, and motor conditions, including hearing-impaired people.

The creation of this AT involved professionals from various fields of expertise, including nurses and computer professionals, noting the importance of the intersectoral approach to the creation of these technological resources. Furthermore, the development of accessible educational materials for distance education depends on the hard work and dedication of those involved in this process.

The increase of DE by the society demonstrates how important it is to provide the web accessibility and opportunity for users with disabilities. In the context of health, the creation and use of internet resources accessible by health professionals, in particular nurses, directly benefit the health promotion of PwD.

The use of technologies by nurses corroborates the care qualification, considering the needs of the individual. Therefore, it is important for these professionals to seek qualification and practical improvement to create technological resources. It is appropriate to stress that professionals from other areas must also use these tools to qualify their assistance[26].

This research contributes to the reflection of health care professionals, especially nurses, on information and communication technologies as a viable educational resource to the teaching-learning process of hearing-impaired people. Distance education benefits from this study due to

important contributions submitted to the digital inclusion of this population.

CONCLUSION

According to the results, we concluded that the pages of the course were appropriate according to web accessibility standards. The errors report issued by the software identified only one failure of accessibility, violating one principle present in the international document. The other notes made by the program consisted of warnings, when the programmer is free to analyze them and verify the relevance of the suggestions so it is accessible to the intended population.

The creation of accessible websites aims to follow the accessibility guidelines and perform automatic assessment, through software, manuals, and users. Despite the careful assessment made by ASES, the course will only be considered fully accessible to hearing-impaired people after user analysis. Therefore, we propose, in future research, a new assessment with the target population.

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ERRATUM

Page 781 **that read**::

"Luciana Vieira de Caravalho[I]".

Read:

"Luciana Vieira de Carvalho[I]".

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