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PEDAGOGICAL INNOVATION? ANALYSIS OF THE USE OF AN ACCESSIBLE DIGITAL TEXTBOOK

INOVAÇÃO PEDAGÓGICA? ANÁLISE SOBRE O USO DE UM LIVRO DIDÁTICO DIGITAL ACESSÍVEL

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ABSTRACT: This article focuses on the use of an accessible digital textbook built based on the perspective of the universal design for learning. The quantitative and qualitative study was carried out in public schools of four teaching networks of Baixada Fluminense, Rio de Janeiro, Brazil, with the participation of 21 students with disability, their teachers from regular classes and the specialized educational service, as well as the classmates. The analysis, according to the cultural-historical theory, problematizes concepts such as pedagogical innovation, pedagogical mediation, and use of technological resources at school.

Keywords: Digital technologies. Inclusive education. Accessible digital textbook. Pedagogical innovation. Special education.

RESUMO: Este artigo trata do uso de um livro didático digital acessível construído na perspectiva do desenho universal para a aprendizagem. O estudo quantitativo e qualitativo foi realizado em escolas públicas de quatro redes da Baixada Fluminense com a participação de 21 crianças com deficiências, seus professores de turmas comuns e do atendimento educacional especializado, assim como os colegas de turma. A análise, à luz da teoria histórico-cultural, problematiza os conceitos como inovação pedagógica, mediação pedagógica e uso de recursos tecnológicos na escola.

Palavras-chave: Tecnologias digitais. Educação inclusiva. Livro didático digital acessível. Inovação pedagógica. Educação especial.

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Introduction

Since the 2000s, we have experienced changes in the Brazilian political guidelines regarding schooling proposals for students with disabilities, especially in the guidelines and programs drawn up based on the National Policy on Special Education from the Perspective of Inclusive Education–known by the acronym PNEEPEI (Brasil, 2008; 2009b; 2011), aligned with advances in the construction of a protective legal system with the Convention on the Rights of Persons with Disabilities (Brasil, 2009a) and the Brazilian Inclusion Law, Law no. 13,146, of July 6, 2015 (Brasil, 2015).

Such political guidelines, based on the principles of human rights, have as their central axis the expanded notion of accessibility in different dimensions: architectural, communicational, instrumental, methodological, curricular, and attitudinal. Thus, based on the documents, accessibility is an imperative to be assumed in research and teaching institutions in order to enable the right of people with disabilities to learn. Although the centrality of accessibility is paradoxical to what it induces, recognizing the limits of this concept, we assume the principles of accessibility based on the idea that diversity is constitutive of the human and the need to construct educational strategies that meet, in the process of collective production of knowledge, the singularities of each student with disabilities or not (Souza; Dainez, 2022).

In this direction, despite legal and pedagogical advances, numerous studies have presented data on the social and educational barriers faced by people with disabilities. This research shows that, in education, one of the main barriers refers to the precariousness of political-pedagogical proposals for curricular accessibility and access to teaching materials. This corroborates the findings of Braun (2012), Dainez (2014), Lago (2014), Pletsch (2014; 2018), Kassar, Rebelo and Jannuzzi (2019), among many others.

According to a survey carried out by Souza, Pletsch and Souza (2020), textbooks are the most used resource in Brazilian public schools, as well as in other countries in Latin America and the Caribbean. However, as already highlighted by the authors, in Brazil, although the National Textbook Program aims to acquire teaching materials for all elementary and high school students, including those who have a disability, totaling around 128 million books distributed (Brasil, 2016), it does not present guidelines or investments for the production of accessible teaching materials necessary to guarantee the participation of people with disabilities in the educational process.

In this context, this paper summarizes the main methodological aspects and results of an investigation that aimed to evaluate and validate a requirements matrix for the production of accessible digital textbooks (ADT), built based on the accessibility principles of the universal design for learning (UDL), considering the specificities of students with intellectual disabilities, low vision, blindness, autism, and deafness. This project was an international initiative carried out by the United Nations Children's Fund (UNICEF) called Inclusive, Equitable, and Quality Education for All. All phases and complete results of the research carried out in Brazil were published in the report, in Portuguese and English[1]. The specific analyses of the study with students with intellectual disabilities and students with deafness were published respectively by Gomes and Souza (2020) and Souza, Pletsch and Souza (2020).

Methodological and ethical aspects

As previously mentioned, this paper presents, in a summarized way, the results of the *Universal Design for Learning Project: implementation and evaluation of the accessible digital book protocol* (*Projeto Desenho Universal para a Aprendizagem: implementação e avaliação do protocolo do livro digital acessível*) (Pletsch, 2018), and the revised UNICEF requirements matrix in the Appendix 1. The investigation was

approved by the Ethics Committee of the Universidade Federal Rural do Rio de Janeiro (UFRRJ), Process no. 23267.000959/2017-76 and Protocol no. 963/2017.

The project was organized in two stages. The first one, in 2015 and 2016, brought together experts from countries in Latin America and the Caribbean, through workshops, to develop standards and guidelines for the production of ADT from a UDL perspective. The idea was to have technical standards and guidelines with which publishers could be equipped to build ADT, so that these books could be made available along with paper textbooks for the education systems of different countries.

In Brazil, among UNICEF's technical partners, the Down Movement[2] coordinated a series of workshops with public bodies, the third sector and researchers in the field of education, in order to develop initial standards and guidelines, focusing on students with intellectual disabilities, as presented by Souza, Pletsch and Souza (2020). The authors describe in detail the stages of this phase, which were organized in workshops based on the following UDL principles:

- Production of information in different media;
- Use of digital format and content manipulation resources (audio description, videos for people with sensory disabilities);
- Repertoire expansion resources (changing the size of text and images, color, animations, sounds, among others);
- Text comprehension resources (box with film tips, books on the content covered);
- Resources for highlighting concepts (anticipating vocabulary, highlighting expressions);
- Image resources (illustrations, photographs, maps, key concepts in image format, icons, symbols);
- Resources for experimenting with concepts (simulations, manipulation exercises, and physical experimentation of concepts);
- Advanced organizer resources (concept maps, glossaries, among others);
- Resources for student expression (activities with oral presentations, videos, texts in different formats, among others) (Cast, 2011; Movimento Down, 2015; Pletsch, 2018; Souza; Pletsch; Souza, 2020).

After preparing the guidelines called pilot, which was validated and improved by other centers in other countries, which focused on people with autism, hearing and visual impairment, the objectives of the second stage were to evaluate and validate the pilot guidelines in elementary schools in Brazil. This second stage took place between 2016 and 2018 (Pletsch, 2018; Souza, 2018; Souza; Pletsch; Souza; 2020).

As described in detail in the *Universal Design for Learning Project: implementation and evaluation of the accessible digital book protocol* (Pletsch, 2018), this stage was under the responsibility of the Special Education and Educational Inclusion Observatory[3] at UFRRJ, with the support of researchers from the Universidade do Estado do Rio de Janeiro (UERJ), in permanent dialogue with the special education managers of the public education networks in Baixada Fluminense, Rio de Janeiro, Brazil, through the Permanent Forum on Special Education in the Inclusive Perspective of Baixada and Sul Fluminense[4].

Here it is worth remembering that Baixada Fluminense is the second largest metropolitan region in Brazil, made up of around four million Brazilians, and one of the territories with the biggest social problems in the country. This peripheral territory, adjacent to the city of Rio de Janeiro, is historically marked by the absence of the State in the development of social policies, marked by a high rate of violence and discrepant indicators in relation to poverty and income, pointing to high levels of inequality (Silva; Oliveira Junior; Borges, 2020). Specifically in relation to education, 11 of the 13 municipalities in Baixada Fluminense were on the list of the 15 worst municipal education networks in the state of Rio de Janeiro in the 2018 Basic Education Development Index, and all municipalities present learning inequality in the synthesis of data from the Inequalities and Learning Indicator (Indicador de Desigualdades e Aprendizagens, 2022).

At this stage of the research, as described in detail in the final investigation report, the activities and the team (teachers, designers, technologists) were organized into four working groups in different areas:

- Choice of a textbook to build the ADT prototype;
- Preparation of the prototype based on the initial UNICEF requirements matrix;
- Modeling and programming of the ADT prototype;
- Application of the ADT prototype in public schools in Baixada Fluminense.

The first step in this second stage of the project was the selection of the textbook. To this end, the most used book in the first grades of the Brazilian elementary schools in 2015 was chosen, according to data from the National Textbook Program/Ministry of Education (MEC). Subsequently, the construction of the prototype for use on a tablet began, based on the following steps:

- Modeling and reviewing a chapter of the social studies textbook (which covers specific science content, but also Portuguese language);
- Review of an accessible digital platform for inserting the textbook content[5];
- Pilot testing of the UFRRJ prototype in a public school in Baixada Fluminense (Souza, 2018; Souza; Pletsch; Souza, 2020);
- Application of the final ADT prototype with evaluation by researchers, basic education teachers, and people with disabilities.

The final prototype had several accessibility devices, namely: menu with the availability of accessibility strategies, Brazilian Sign Language (LIBRAS) window for each utterance and activities, sound buttons, text reader with accompaniment in highlighted colors, enlargement of letters, audio description of images, contrasts between text and screen background, images and videos related to the concepts of the didactic unit, supporting links with other forms of presenting concepts, among other devices, organized into low, medium and high complexity resources/strategies.

For the research stage in schools, four field teams were organized and were responsible for the following areas: intellectual disability, deafness, visual impairment (blindness and low vision), and autism. It is important to mention that these teams participated in three training seminars to deepen and align the theoretical-methodological aspects for the development of research activities in schools.

As discussed by Souza (2018), in parallel with the development of the project, continued training was carried out with 200 teachers from ordinary teaching classes and specialized educational service (SES) through a 120-hour extension course on technology and accessibility. The digital book prototype was applied at the school of some of the participants in this training. It is worth mentioning, albeit briefly, that at this stage two meetings were held with regular classroom and SES teachers with the aim of presenting the tablet material, analyzing the suitability of the content and accessibility strategies of the book, and pedagogical mediation strategies were structured with the use of the book in their classes in partnership with the research team.

The interventions took place in classes in regular classrooms and in the SES with students with intellectual disabilities, autism, and low vision. This strategy made the evaluation of different issues possible, such as: interaction, participation, collaboration between peers, and the usability of the ADT by the subjects individually and collectively with their classmates.

In the case of deaf students, as indicated by the PNEEPEI (Brasil, 2008), the research took place in two bilingual classes in the first cycle of elementary school, two meetings in the classroom and two in a computer room where SES activities took place, as described by Gomes and Souza (2020). For blind students, most teaching networks organize classrooms and affiliated schools so that they, at the beginning of their school trajectory, have access to Braille and learn how to use other assistive technology resources. This strategy

has been an alternative adopted by education networks, as the region faces difficulties in hiring specialized teachers to work in schools and to acquire technological resources.

Five public basic education networks participated in this stage of the study, including: 21 students with disabilities (five with intellectual disabilities, four with autism, four with blindness, four with low vision, and four deaf students), around 350 classmates of students with disabilities enrolled in four regular classrooms, 21 teachers from regular classes and 17 SES teachers, all from the first grades of elementary school. We also counted on the engagement of managers of the special education modality.

The average age of participants varied greatly: 31% of them were between 7 and 8 years old, 10% between 8 and 9 years old, 48% over 9 years old, and 11% did not inform their age on the registration form. Considering that the research focused on the first grades of elementary school, it is possible to say that there is an age-grade gap, indicative of the schooling process of students with disabilities combined with life in a situation of social vulnerability of the population involved in the study.

The number of students per classroom surveyed also varied greatly. Here it is important to remember that classes for deaf students and students with visual impairments (blind and low vision) have a smaller number, considering the specificities of the work carried out. In regular classrooms with students with autism enrolled, for example, we found a small number of students per class, between 14 and 17 children, if we consider the average of 25 students per class in Brazil. Regarding teachers, although the study included some teachers with little time working in public schools, the vast majority have graduate degrees and more than 20 years working with students with disabilities.

All interventions were recorded in video, photographs, and field diaries. We also counted on recorded observations on accessibility indicators and pedagogical mediation strategies in two semi-structured instruments designed to be completed by researchers during interventions. This instrument generated quantitative data for the study.

In the analysis process, with the participation of basic education teachers, initially, each team presented the data constructed in a quantitative and qualitative way. Subsequently, collectively, team analyses were organized in dialogue with the assumptions of the historical-cultural theory and with the production in the area to prepare a first review of the protocol (requirements matrix).

Once in possession of the revised protocol, its submission for consideration in two public hearings in a seminar format was held. The first one included a study and review of the document by researchers in the field and users; and, in the second one, the participation was expanded to professionals from participating schools, managers from Education departments, and people with disabilities, autism spectrum disorder, deafness and their families. These public hearings were important for producing the final protocol (see Appendix 1), and also contributed to socially validating the results. This perspective considers as a research premise the idea of producing knowledge *with* the participants and not *about* them or *about* their educational actions (Pletsch; Souza, 2021).

Accessible digital textbook: Limits and possibilities in building teaching relationships

Our analyses highlighted numerous questions about the usability of the ADT from the perspective of the UDL, which enabled the review of the initial protocol and the construction of questions regarding the role of the ADT in teaching relationships, understood from the idea of "conceiving human development and teaching/learning processes as ways of appropriating culture and participating in social practices. [...] a way

of understanding knowledge and the very ways of knowing, as human production" (Smolka et al., 2008, p. 9, our translation). Among the issues raised, here we deal with the usability of the tablet and the ADT, and the role of the UDL in pedagogical mediation strategies.

Regarding the tablet usability, only 47% of students with disabilities were aware of this type of device before the survey at school. During the intervention process, 67% of students were able to perform equipment commands and access the book, and 46% of them were only able to handle the tablet with support from teachers, even for simple commands such as turning it on and off. This fact was also noticed with the other students enrolled in the classroom.

Such information is important when we confront the idea that the generation that is at school is made up of *digital natives*. In this study, carried out with students who mostly live in poverty and extreme poverty, the lack of knowledge about the tablet and the difficulty in handling and accessing the equipment applications was a factor that impacted the investigation process. There was also, in some cases, a mismatch between the content of daily life routine that was in the book used to develop the prototype, which was the most used in schools in Brazil, and the students' life context. For example, one of the students did not consider the bath activity as a daily activity, and another student had difficulty recognizing and understanding the meal that is eaten at night, because in his house there is no dinner–the place for eating is in the school.

In addition to living in a situation of disability, poverty also poses as a barrier to access the knowledge and has a crucial impact on the social conditions of development. Unlike what is advocated in several political documents, technological equipment in itself is not a direct way of confronting inequalities (Souza, 2021), and accessibility as a human right must carry within it the assumption that social, economic, and political inequality is, above all, the main barrier that structures the processes of exclusion of rights in our country.

In relation to handling and accessing the content of the ADT, such as locating the information in the statements, understanding what was being required to carry out the activity and searching for support resources, even with different accessibility devices, the students had difficulties in selecting the activities. Among the actions evaluated, in general, around 70% of students were only able to handle and access the ADT with the support of teachers and/or researchers. It is worth remembering, as previously reported, that many students were not aware of tablet equipment before the research.

Regarding some singularities about the usability of ADT, it is important to highlight that in the previous meeting with the teachers it was indicated that the LIBRAS windows, with videos of a teacher signaling and interpreting the content of the book, would not be as accessible to students, due to the delay in acquiring sign language and, therefore, the difficulty in understanding academic content. Thus, the use of other support resources, such as ADT images and pedagogical resources/objects available in the classroom, was fundamental in the process of pedagogical mediation with the concepts that made up the ADT (Gomes; Souza, 2020).

When carrying out the activities, only 4% of students were able to read, interpret and carry out the activity independently, which is not far from the behavior of students in the process of interacting with teachers in the classroom when they are asked to answer a question about the content of the book. In these situations, only 6% answered the demands with greater autonomy, and 59% demanded more specific support from teachers and researchers, such as examples from everyday life so that they could understand the concepts taught in class.

Another issue that became evident in this regard was the use of pedagogical resources/objects complementary to the ADT, such as: Montessori golden beads, conceptual maps and ideas, miniature objects, mirrors, dolls, interlocking puzzles, hygiene items (such as toothbrushes, soap, etc.). During the intervention process, most of the pedagogical mediation strategies proposed by the teachers were based on the use of these resources/objects as support for working with the concepts covered in the ADT–as, for example, in the case of students with congenital blindness, who, in addition to presenting singularities in the symbolic

construction (Pitano; Noal, 2018), were at the beginning of the literacy process. Thus, even with audio description resources in the ADT, the use of miniature objects and resources in pedagogical mediation strategies was essential for the knowledge construction process. Not far from that, with students with autism and those with intellectual disabilities, the use of pedagogical resources/objects in pedagogical mediation strategies were also fundamental for attention and understanding the statements and concepts of the ADT, which coincides with the analyses of other studies (Braun, 2012; Pletsch; Mendes; Hostins, 2015; Almeida, 2016; Campos, 2016; Silva; 2016; Souza; Pletsch; Souza, 2020; Tretin, 2018).

As previously reported, recognizing the power of accessibility strategies and student motivation caused by the use of ADT, the teaching work was central in the construction of teaching relationships and pedagogical mediation strategies, which leads us to analyze the role of technological instruments. Assuming that teaching/learning is a process of interaction and sharing (social and collective human practice), the centrality is in human and semiotic mediation in the relationships between the student, the mediator (mainly the teacher, but also their peers) and knowledge, which occupies a central place (Vygotski, 1997; Vigotskii, 2010). In these terms, even though it has great potential for students with disabilities to interact with knowledge, the role of the ADT is to support pedagogical mediation strategies.

Some considerations

Given the data and analyses presented in this text, it is possible to infer that the teachers' pedagogical work proved to be decisive so that students could not only handle and use the ADT on a tablet, but also that, without pedagogical mediation, most students would not have benefited from the pedagogical resource in an accessible digital format from the perspective of the UDL.

In this sense, the research highlighted three important aspects for us to reflect on the use of technology in the classroom, as described in detail by Pletsch (2018). These three aspects were also identified in the pilot study with students with intellectual disabilities (Souza, 2018; Souza; Pletsch; Souza, 2020) and in research involving students with deafness (Gomes; Souza, 2020). These aspects are:

- The teachers' pedagogical mediation was crucial for students to benefit from the pedagogical resource in digital format on a tablet. Therefore, the use of the technological pedagogical resource of the ADT on a tablet proved to be another teaching resource that, depending on the use and mediation, favors or not student learning;
- The students that participated in the project were not digital natives as is commonly repeated in scientific literature and the media, but they are inserted in social contexts in which technology is present, mainly through the use of cell phones. The research showed that a significant number of students had never handled a tablet, but many knew how to use technological resources present in the book, such as zooming to enlarge something that one wants to see better, looking for icons to command an action, scrolling the presentation on the screen in a curious and intuitive way, seeking new things.
- The ADT on a tablet proved to be an attractive and dynamic tool, which generated interest in current affairs and in the variety of possibilities that allow the use of various resources–image, voice, video, sound and visual feedback, for example. However, it is important to clarify that it constitutes another didactic mediation resource, like so many others, that can be used in the classroom, in order to guarantee the teaching and learning processes for all students, regardless of the specificities in development that each person may present, as the case with the special education population, in order to expand the possibilities of educational and, consequently, social inclusion.

Based on these inferences, we evaluated the UNICEF requirements matrix and restructured it with a series of technological and pedagogical recommendations, in order to guarantee greater accessibility to digital textbooks, in accordance with the principles of the UDL. The protocol can be applied to digital textbooks at three levels, namely:

- Low cost or low complexity: encompasses only a set of functions;
- Medium cost or medium complexity: encompasses the functions present in the previous item and must incorporate new ones;
- High cost or high complexity: encompasses all of the above and also presents technological improvements that require greater financial costs.

All items were evaluated by users with disabilities and researchers in the area and were validated in a public technical hearing open to society, as described in the text, with broad participation of social movements of people with disabilities and education professionals from different education networks in Baixada Fluminense.

Finally, the problematizations raised in this text are relevant for their pioneering nature, as they focus on the role of ADT as a significant instrument for the improvement and expansion of inclusive education policies, materializing pedagogical innovations in technological tools. Furthermore, they highlight the centrality of the teacher's pedagogical mediation in the educational process. In this sense, the idea of pedagogical innovation seems to be more focused on the teacher and the strategies for mediating teaching relationships than on the technological tool itself. However, technological resources such as the ADT are important allies to expand educational accessibility for this portion of the population, in order to strengthen their autonomy, their educational and social inclusion, and, therefore, expand their opportunities to improve their quality of life. Likewise, it is worth saying that there is little or no research on accessibility in digital textbooks for people with intellectual disabilities, autism, and low vision. In this sense, the protocol, a product of this project, is an important scientific and social contribution, as it presents a set of technological and pedagogical possibilities.

Conflict of interest

Nothing to declare.

Data availability statement

All dataset were generated or analyzed in the current study.

Authors' contributions

Conceptualization: Pletsch MD, Souza FF; **Data curation:** Pletsch MD, Souza FF; **Funding acquisition:** Pletsch MD, Souza FF; **Investigation:** Pletsch MD, Souza FF; **Methodology:** Pletsch MD, Souza FF; **Validation:** Pletsch MD, Souza FF; **Writing – original draft:** Pletsch MD, Souza FF; **Writing – review & editing:** Pletsch MD, Souza FF; **Final approval:** Pletsch MD.

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Notes

1. UNICEF's initial requirements matrix available at https://www.accessibletextbooksforall.org/es/historias/requerimientos-para-el-usuario. Accessed on: Mar. 20, 2023. Final reports of the project developed in Brazil are available at https://obee.ufrrj.br/wp-content/uploads/2018/09/Projeto-Desenho-Universal-para-a-Aprendizagem-Implementa%C3%A7%C3%A3o-e-avalia%C3%A7%C3%A3o-do-protocolo-do-livro-digital-acess%C3%ADvel.pdf and https://encontrografia.com/978-65-88977-67-5/. Accessed on: Mar. 20, 2023.
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4. The Permanent Special Education Forum from the Inclusive Perspective of Baixada and Sul Fluminense was created in 2015 within the scope of Special Education and Educational Inclusion Observatory/UFRRJ.
5. A first version of the prototype was produced in 2016 by Pedro Milliet, based on recommendations from the team coordinated by the Down Movement, formed by the researchers Márcia Denise Pletsch (UFRRJ), Patrícia Braun (UERJ), Márcia Marin (Colégio Pedro II), Talita Matos (Movimento Down) and Daniela Marçal (Movimento Down).

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Appendix 1. Final protocol*.

MANDATORY REQUIREMENTS				
FEATURES	**Hearing impairment and deafness**	**Low vision and blindness**	**Intellectual disability**	**Autism**
Screen lighting It must allow for the adequacy of screen lighting on the equipment.		x		
Standard font The standard font should be *sans* serifa, in bold and uppercase: Arial, Tahoma or Verdana		x	x	
Activating and deactivating functions It must be possible to activate and deactivate all its functions, including: sounds, audios, videos, moving objects, subtitles in local language, video local sign language, etc. Activation and deactivation of functions must be available by various means, such as: audio, vibration, writing and touch screen. There should be also a command to keep activation permanently.	x	x	x	x
Permanence on the textbook There should be a command that keeps the textbook on screen, preventing the user from exiting the textbook when necessary.	x	x	x	x
Scroll by page The textbook format must allow scrolling by page, page turning or by link.	x		x	x
Screen orientation Screen orientation must be available in portrait and landscape. There should be a command that allows the preferred screen orientation to remain the same, to avoid confusion and disorientation.	x	x	x	x

Touch and drag functions on the screen The screen of the device on which the textbook will be installed must allow to work on the textbook by touch. This attribute must enable: user interaction with the textbook: drag elements of the interface when moving a finger on the screen; listen to screen content (with or without vibration); point/click without dragging.	x		x	x
Character enlargement It should be possible to expand a typed font adaptable to the needs of each student, with the possibility of 39 characters per line (significant spacing between characters) and 1.5 spacing between lines.		x		
Colors and background contrasts Changing the colors must be made available, enabling the interface with contrast between letters (others) and background in: yellow/black, white/black, yellow/blue (royal), white/dark green, etc. The use of pastel shades of colors that are not always perceived, giving the appearance of a stain, should be avoided.		x		
Screen reader A screen reader feature that reads statements, icons, images or any other printed element must be available.		x		
Sound information Audible feedback must be available to acknowledge a command given by the user, in reference to an operation, such as an answer or the confirmation that a key has been pressed on the screen or a request to end an action.		x	x	x
Tactile information by vibration Vibration feedback must be available to inform a command given by the user, in reference to an operation, such as an answer or confirmation that a key has been pressed on the screen or a request to end an action. The vibration function must be available in all activation commands and interaction with the software.	x	x	x	x
Alternative communication Access to and use of an image bank must be available from alternative communication symbols and box for the user's sentence registration or textual production.			x	x
Video window with local sign language Video windows with a deaf and/or hearing teacher or interpreter who signals in local sign language the content of the text or activities must be available. The video must have Chroma Key (green) as background. When necessary, in accordance with the content and the moment of the user's development, it is desirable to use scenarios and objects contextualizing the content worked.	x			
Audio description The audio description must be available to the user, when necessary, to access information available in the textbook, such as: images, drawings, videos, pictures or graphs. (Ideally, the recording should be done by human voices, with vocabulary and local accent.)		x	x	x
Description in audio Resources to highlight vocabulary with typed expressions, iconic, graphic systems of alternative communication, in audio that enable the understanding of the concept/content/subject covered in the text, image, graphic, statement, etc. must be available.		x	x	x
Subtitles All audio and video recordings must have subtitles in local language and a window with video in local sign language, synchronized with the referring text.	x		x	x
Text subtitles for the deaf All audio and video should be supplemented by local language subtitles with color-enhanced synchronization with local text and sign language.	x			
Adjustable orientation or placement of video on screen The function of moving the video up, down, right and left must be available in the settings for the user's choice. This function must allow subtitles in local language and/or in local sign language to move along with the video.	x		x	x

Adjustable video size The video window size must be available in the settings for the user's choice: small, medium or large.	x		x	x
Video manipulation with local sign language The video from the local sign language window must be user manipulable allowing: rewind, pause, and fast forward. As well, it must allow content speed adjustment, allowing the user to adjust for better understanding of the signaled content.	x			
Interactive texts and buttons with icons and symbols referring to the local sign language The texts in local written language must be adequate to the level of comprehension of the user whose first language is sign language. When necessary, symbols and images should be used to support the text. When using interactive buttons, use them in icon and symbol format.	x			
Direct access to content It should be possible to access, from icons, other layers of information and resources, such as glossaries, videos, maps–avoiding too many distractors on the same page.			x	x
Illustration caption Captions must be presented next to the image that refers to it.	x	x	x	x
Colors and outlines of illustrations Outline of illustrations should be well defined and in high contrast. In addition to the use of well-defined colors, with uniform filling that visually demarcates the details of the illustration.		x		
Illustrated area There must be a delimitation of the area of illustration (it facilitates the understanding of the focus/subject/relation in question).		x		
Text adjustment Adaptable fonts must be available to make the textbook more accessible, such as: adjustable colors, background contrast, line spacing, word spacing, and simply organized layout with zoom functions.	x	x	x	x
Zoom adjustment It must be possible to reconcile the zoom with the rest of the information so that the context is not lost and to avoid spatial disorientation of the user.	x	x	x	x
SYNCHRONIZATION				
Menu All adaptations aimed at specific needs must be available in a menu in which the user can choose his/her preferences and create a profile that stores this information. The menu must be accessed by sound, vibration and optional voice feedback, for signaling the command, which needs to have several options to be activated according to local sign language, icon or symbols. The speech synthesis feature must be available to record the user's answers or oral readings. It must be possible for the user to include or modify statements, vocabulary, activity, according to the profile. It must be possible, by means of a simple touch, to identify the options so that it is possible to create a personalized profile, as well as select the user's preference through double-tap on touch screens.	x	x	x	x
Synchronized video All videos must be synchronized with the text, image, exercise or graph, which must be available next to the corresponding reference.	x		x	x
Video window with synchronized sign language The video window with local sign language must be opened next to the related content (text, image, exercise or graph), making it possible to follow the signed content in local language. When the textbook is aimed at users not yet familiar with the sign language symbol, the window should be open next to the text, ready for the video to be played.	x			
Synchronized narration and audio description The narration and audio description must be synchronized with the text, headings, page numbers, paragraphs, titles and references, table of contents, glossary, images, videos, graphs, exercises, and references.		x	x	x

Text highlighting synchronized with audio content When there is audio content, there must be a highlighted text that accompanies the spoken content, helping to read the content being narrated.	x			
Navigation with content tagging A function that allows navigation within the document with content tagging must be available. The text must be tagged with the structure of the textbook, including headings, page numbers, table of contents, glossary, images, videos, graphs, exercises, and references. The tagging or selection of items must be triggered through hardware such as the keyboard with custom tagging or in Braille.	x	x	x	x
Text highlighting by touching or by moving the cursor via mouse The feature to highlight all text in the textbook (through colors and sounds) must be available when the user browses (or searches, hovers the cursor) with the mouse or finger over the textbook.	x	x	x	x
Narration (text to speech) The content of the textbook must be available in narration format, including headings, page numbers, paragraphs, titles, and references. The narration must be synchronized with the text. (Ideally, the recording should be made using human voices, with local vocabulary, and accent.) During the narration, the text must be highlighted, allowing the reading to be followed.		x	x	x
PEDAGOGICAL ASPECTS				
Glossary The textbook must have a glossary with the definitions of the concepts presented with the option of text, icon/symbol, audio, narration of the word, phonetic spelling and local sign language video, and alternative communication stock images. The glossary must have the option of spelling words so that the user can consult it in case of doubts on spelling or in the reading/writing construction phase.	x	x	x	x
Advanced content organizers Availability of resources that contribute to the systematization of information/content/concepts presented in activities, such as: concept or mind maps, timelines, glossary of images, word bank, infographics, phrasal sequencing for textual production.			x	x
Relation and analysis between/through associated icons or indicative arrows Resources to synchronize texts with visual resources (image, graph, concept or mind map) must be available.			x	x
Content of illustrations The illustrations used must be simple and contextualized, containing only the elements that are significant to what is dealt with in the activity/ proposal.	x	x	x	x
PREFERRED REQUIREMENTS				
Standard size of interactive items All interactive buttons, images or icons must be at least 9 by 9 mm. There must be a distance of at least 1 cm between one icon and another one when they are close, allowing for better visualization and tactile contact.	x		x	x
Speed control of interactive features The user should be able to adjust the speed of all interactive features, such as: narration, videos, screen elements of the local sign language.	x		x	x
Electronic memory The software must be able to store information such as preferences and layout, answers to exercises, and mark where the student last opened the textbook; the software must keep the answers to the exercises registered and visible on the screen; the software must offer "resume button" feature to clear and restart responses.	x	x	x	x
Data storage A repository or database that stores the entire content of the electronic memory must be available.	x	x	x	x
Sending data It must be possible for the user to have access to his/her answers in a personal file, sent by email or other means of sharing, for study purposes.	x	x	x	x

FUTURE ENHANCEMENTS				
Interactive support The software must allow interactive inputs, in various language formats: oral, video, photography, drawing, chart/summary, lecture (word bank for automatic completion) etc.	x		x	x
Voice recognition The software must allow speech recognition that converts spoken words into typed text.			x	x
Direct access to other applications and features of the device The direct access to other applications and devices from the tablet or cell phone must be available.	x	x	x	
Interaction between devices Interaction with other devices (tablets, cell phones) must be available.	x	x	x	x
Voice location The location of subjects and activities through voice command must be available.		x	x	x
Spelling The resource of spelling, complementary to the resource of audio, audio description, selection, and reading of words must be available. The spelling feature minimizes comprehension deviations caused by reading in an electronic voice and/or words spelled with foreign words.		x	x	x

*Elaborated after research carried out based on the UNICEF initial requirement matrix on accessible digital educational books by Márcia Denise Pletsch, Patrícia Braun, Márcia Marin and Flávia Faissal de Souza (Pletsch, 2018).