Scientific Technical Report

Universal Design for Learning Project: Implementation and evaluation of the accessible digital textbook protocol

Márcia Denise Pletsch

encontrografia

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Sumário

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Introduction

This project emerged in 2016, after conducting a series of workshops in several countries on the accessibility of digital textbooks sponsored by the United Nations Children's Fund (UNICEF) in 2015. The international initiative called *Inclusive, equitable, and quality education for all* brought together experts from several countries in Latin America and the Caribbean to develop guidelines for the production of accessible textbooks from the perspective of the universal design for learning. In Brazil, the responsible body for organizing the thematic workshop was the Down Movement. The guidelines of this international initiative, published in the country by the Down Movement, served as guiding **principles** of the work developed throughout this project with regard to Universal Design for Learning – UDL (MOVIMENTO DOWN, 2015)[1]. The aim of the project was precisely to apply and evaluate the indications already existing in the UNICEF protocol for textbooks from the perspective of the UDL. This report summarizes the main aspects and results of this project.

The protocol (Annex 1) used as the basis was prepared by an internal team organized and coordinated by UNICEF. This protocol served as the

1 Material in Portuguese available at: http://www.movimentodown.org.br/wp-content/uploads/2015/08/Manual-FINAL-bibliografia.pdf. Accessed on: Sept. 20, 2016.

basis for the elaboration of the accessible digital textbook prototype, which was applied and evaluated with children from public schools in four municipal education networks in Baixada Fluminense/Rio de Janeiro – RJ/Brazil (Belford Roxo, Nova Iguaçu, Mesquita and Duque de Caxias).

Baixada Fluminense has approximately four million inhabitants and is made up of thirteen municipalities (RIO DE JANEIRO, 2021). The social reality of this region is marked by low Human Development Indices (HDI), high rates of school dropout, high precariousness in public health services, lack of basic sanitation, poor quality public transport and high rates of urban violence (PLETSCH, 2018).

The project activities, whose results will be presented here, were developed within the scope of the Observatory for Special Education and School Inclusion (ObEE)[2], a research group based in the Multidisciplinary Institute, campus of the *Universidade Federal Rural do Rio de Janeiro* (UFRRJ) in Nova Iguaçu, with the support of researchers from the *Universidade do Estado do Rio de Janeiro* (UERJ), in permanent dialogue with the Special Education managers of public school networks in Baixada Fluminense, through the Permanent Forum of Special Education in the Inclusive Perspective of the Baixada Fluminense (Forum)[3]. The project also had the fundamental support from the Down Movement and its team. To carry out the research, in addition to the resources of a Parliamentary Amendment (LOA/UFRRJ), we also had, in the first phase of the project, with the support of the Carlos Chagas Filho Foundation for Supporting Research in the State of Rio de Janeiro (FAPERJ), through Public Notice 4/2016, and the National Council for Scientific and Technological Development (CNPq), through the 2015 Human Sciences Public Notice.

All research procedures were analyzed and approved by the UFRRJ Ethics Committee, under Protocol Number 963/17 (Process 23267.00959/2017-76), according to the indications of Brazilian Resolution Number 466/2012.

2 Available at: http://r1.ufrrj.br/im/oeeies/

3 The Permanent Forum of Special Education in the Inclusive Perspective of Baixada Fluminense was created in 2015 by the ObEE. It currently has the participation of Special Education managers from Baixada Fluminense and two public universities in the region (UFRRJ Campus Nova Iguaçu and UERJ Campus Duque de Caxias).

Theoretical framework of the research

Since 2008, we have experienced different changes in federal policy standards regarding the schooling proposals for the Special Education public (people with intellectual and sensory disabilities, pervasive developmental disorders and giftedness), especially with the implementation of the National Policy on Special Education from the Perspective of Inclusive Education (BRASIL, 2008) and the Operational Standards for Specialized Educational Services in Basic Education, Special Education modality (BRASIL, 2009). Such documents, among other aspects, show that inclusion must take place at all levels of education, from Early Childhood Education to Higher Education. Another indication refers to specialized educational support, which should take place, primarily, in multifunctional resource rooms through the Specialized Educational Service (SES), understood as a complement and supplement to common teaching, and not as a substitute space for schooling, as it used to be — and it still occurs in some states — in special classes and schools (BRASIL, 2008, 2009). Despite legal advances in terms of inclusion, numerous studies have identified the existence of a set of barriers to guarantee the teaching and learning process of these subjects. Among them, one of the biggest is the non-learning of people with disabilities due, among other aspects, to the lack of flexibility and access to school curricula (BRAUN, 2012; SOUZA, 2013; PLETSCH, 2014a, 2014b; LAGO, 2014; MARIN, 2015). In this

sense, the debate on curriculum accessibility becomes essential for the construction of teaching and learning strategies and practices for these students.

We understand that curricular flexibility refers to changes and strategies organized by teachers in their practices, in order to meet the demands of students with specificities in the learning process. However, these changes are not associated with the limitation, cancellation or impoverishment of the contents or objectives to be proposed to the student, but rather with the review of strategies and technological resources (or not) used so that students with disabilities or other specificities in development can actually learn. This means that it is not

> [...] about preparing another curriculum, but working with what is adopted, making the necessary adjustments to it (flexibility in objectives, content, teaching methodology, temporality, and learning assessment practices) in order to offer everyone the true equality of opportunity to build knowledge (CARVALHO, 2008, p. 105).

In this context, the concept of *universal design* is inserted, which in its genesis proposed to expand accessibility to physical spaces and the use of artifacts and communication resources that could guarantee access and participation of all people, regardless of their sensory or physical specificities, aiming to guarantee full conditions of access to mobility, communication and knowledge. In other words, the concept of *universal design* expanded the scope of the notion of accessibility beyond the physical aspects. Thus, the concept refers to both people with disabilities and people with reduced mobility due to an accident, medical condition, or due to advanced age (CAST, 2018; ZERBATO, 2018).

In the Brazilian legislative field, for example[4], it was in the late 1990s that this issue gained more space. To illustrate, we can cite the Decree no. 3,248, of December 20, 1999, which defines *technical aids* and establishes norms on accessibility for bodies and entities of the Federal Public Administration (BRASIL, 1999). *Technical aids* or *assistive technologies*, in this Decree, were understood as working materials specially designed or adapted; elements of mobility, care and personal hygiene required for autonomy and

4 On an international scale, the work of disseminating and elaboration of guidelines for the implementation of the concept of universal design has been the responsibility of the United Nations (UN).

safety; special elements to facilitate communication, information and signaling; environmental adaptations and others that guarantee access, functional improvement and personal autonomy (PLETSCH, 2017). In December 2004, this conception was expanded and the concept of universal design was incorporated in Decree no. 5,296, of December 2, 2004 (BRASIL, 2004). It is worth mentioning that the guidelines contained in these legal provisions can also be found in the accessibility standards published by the Brazilian Association of Technical Standards (ABNT).

In official terms, we can also highlight the indications of the National Plan for the Rights of Persons with Disabilities – Living Without Limits (Decree no. 7,612, of November 17, 2011), which instituted the National Program for Innovation in Assistive Technology with the objective of supporting product development, methodologies, strategies, practices and innovative services that enable the increase of autonomy, well-being and quality of life of people with disabilities (BRASIL, 2011).

Taking this perspective as a basis, we understand that the concept of *universal design* must also be incorporated into pedagogical practices aimed at students who are part of the Special Education population. Likewise, the school needs to review its conceptions of curriculum and the different dimensions that constitute it, in order to respond adequately to all students, guaranteeing them access to school knowledge. This posture of the school institution necessarily requires changes in pedagogical practices, which, in turn, is related to the curriculum concept adopted by the institution. It also depends on the pedagogical resources made available to teachers to plan and operationalize teaching.

Based on these considerations, we understand that the concept of *universal design* represents an advance in the schooling process for people with disabilities, as it makes it possible to structure the curriculum in general so that *everyone* has access, unlike in previous times, when the curriculum for students with disabilities was different from that offered to other students. This possibility of personalizing teaching[5], respecting the difficulties and talents

5 The proposal of personalized teaching is an international trend and has been used to favor pedagogical practices with the diversity of students present in the classroom in order to enable the development of individual skills and talents. Available at: http://www.porvir.org/especiais/personalizacao/. Accessed on: October 26, 2015.

of students, through the use of differentiated pedagogical strategies, can considerably expand the inclusion with academic and social development of the subject with disabilities. However, we warn that individualizing teaching:

> It does not mean to particularize the pedagogical action to the point of separating the student from the group. The purpose of individualization is to include them in the learning situation that others are experiencing, with the necessary adjustments so that their participation is effective. It is to meet the individual differences that the student may present as a result of the specifics of their development (MARIN; BRAUN, 2013, p. 56).

In this sense, we once again emphasize the importance of the concept of the UDL, which consists of offering students a set of flexible strategies, practices, techniques and materials to ensure their participation in educational processes, as we understand that each subject is unique and responds in a unique way to pedagogical stimuli and opportunities. In other words, the UDL proposal suggests access and learning conditions for all subjects present in the school context, from the offer of multiple and varied ways to organize and make available scientific knowledge.

Some of these possibilities consist of reviewing the organization of the classroom space, in which students could have a "voice" and participate in the construction of their knowledge, interacting more with each other. More collective activities could also be offered or developed through "peer mentoring", in the form of collaborative learning. This practice also suggests that "more advanced" peers help students who are still building their knowledge on the subject addressed by the teacher (FONTES et al., 2009; GLAT; BLANCO, 2009; BRAUN, 2012; MARIN, 2015). Other examples of pedagogical strategies relate to material issues and experiences that create opportunities for recognition of the concept worked by the teacher, as well as the creation of didactic resources – such as explanatory diagrams with illustrations and keywords on the subject discussed, in addition to the reorganization of time and the criteria required in the school space. It is with this perspective that a set of technological resources and strategies have been developed to ensure curriculum accessibility for the diversity of subjects present at school, focusing, above all, on blind people. For example, in Brazil we can mention the accessibility devices for the digital textbook

accessible via Mecdaisy[6], which allows the generation of digital spoken textbooks and their reproduction in audio, recorded or synthesized. Access to textbooks for people with intellectual disabilities[7], autism and low vision is still not guaranteed.

Taking into account that the textbook is the most used pedagogical resource in Brazilian schools and in other countries in Latin America and the Caribbean, the proposal for the elaboration of a protocol that highlights and guides the elaboration of textbooks based on the concept of universal design for learning is of great importance, given the demands placed on the educational and social rights of all people, including those who make up the Special Education audience. This proposal can benefit and expand the educational and development possibilities of this population, as well as their social and labor inclusion.

In the Brazilian case, the use of technology has been present in national Special Education policies from an inclusive perspective. Analyzing the data from the 2015 Consolidated Management Report of the Ministry of Education (BRASIL, 2016) regarding the fulfillment of the Goal that deals with the expansion of enrollments of Special Education students in the regular and public education network, we note that the budget expenditure was limited to the acquisition or adaptation of technological equipment. Some examples are:

> From 2012 to 2014, 17,500 multifunctional resource rooms [MRR] were implemented in 4,785 municipalities and 30,000 existing rooms were updated, corresponding to an investment of 354.8 million BRL. In 2015, 20,000 schools were served, with the Virtual Vision program made available to students with disabilities. In addition, 42,000 schools with MRRs received the Prancha Fácil [Easy Board] software [...]. Through the Accessible School PDDE [Direct Money at School Program], from 2012 to 2014, 28,954 public schools were benefited, with financial resources of 312 million BRL to promote architectural accessibility.

6 Available at: http://intervox.nce.ufrj.br/mecdaisy/. Accessed on: October 25, 2015.

7 According to the 2017 microdata from the National Institute for Educational Studies and Research Anísio Teixeira (INEP), around 70% of enrollments in Special Education in Brazil are directed to students with intellectual disabilities

> With the objective of eliminating barriers to school inclusion, in the period 2012-2015, within the scope of the Caminho da Escola Program, 2,482 accessible urban buses were acquired with resources from the Ministry of Education (BRASIL, 2016, p. 43-44).

Also in the same document, other data that matter for this report and whose focus is the universal design for learning are those referring to the National Textbook Program (PNLD), which aims to acquire teaching materials for all students, including those who have a disability. Literally:

> In the period 2012-2015, approximately 5.9 billion BRL were allocated for the acquisition and distribution of more than 616 million textbooks, in addition to dictionaries and complementary pedagogical works, serving more than 30 million students a year, in approximately 135,000 schools and partner entities. In 2015 alone, 1.4 billion BRL was earmarked for the acquisition and distribution of textbooks to elementary and high school students. In this way, more than 32.6 million students from 121.5 thousand schools were served, totaling around 128 million books distributed (BRASIL, 2016, p. 38-39).

However, in the amount above there is no mention of the production of teaching materials from the perspective of the UDL, or even made from parameters that can guarantee access to the content for Special Education students. It is for this purpose that this report provides data that can contribute to the production of scientific and technological knowledge, particularly with regard to the learning of people with intellectual disabilities, low vision, blindness, autism and deafness. In this way, it intends to join the international discussion on the quality of education offered in public schools, based on the concept of the UDL. This report is also relevant for its pioneering spirit, as it focuses on the role of the accessible digital textbook as a significant instrument for the improvement and expansion of inclusive education policies, materializing pedagogical innovations in technological tools. Such an undertaking may expand educational accessibility to rural and urban populations in Brazil and other countries, strengthening their autonomy and social inclusion and, therefore, expanding their opportunities to improve their quality of life.

Research objectives

General Objective

- To implement and evaluate the UNICEF universal design for learning protocol for accessible textbooks in the schooling of students who make up the Special Education population included in different educational realities.

Specific Objectives

- To monitor and analyze the insertion of the digital textbook in the schooling of Special Education students.
- To map the possibilities and demands presented by teachers in the use of digital textbooks for Special Education students.
- To evaluate the universal accessibility prototype for textbooks from UNICEF and its applicability in the schooling of Special Education students.
- To develop guidelines for publishers participating in the National Textbook Plan (PNLD) for the production of accessible digital textbooks.

Methodology

In this item we present the procedures adopted for the development of the research project, the data collection spaces and the research subjects, as well as the instruments used.

The research was carried out in three distinct phases, interconnected with each other.

First phase – from 2016 to 2018

The first phase involved different actions, some of which started in 2016. Below there is a brief description of the different procedures that preceded the application of the accessible digital textbook prototype in schools.

- Modeling and adaptation of a textbook chapter in the area of Social Studies (which covers specific science content, but also Portuguese language) used in Elementary School. As a criterion for selecting textbooks, we chose to focus on those that were most used in 2015 by the National Textbook Plan. This phase began in 2016 with the coordination of the Down Movement and was completed in 2017 by the UFRRJ field research team.
- Review of the accessible digital platform for textbook contents. Here, it is important to mention that a first digital version was produced,

in 2016, by Pedro Milliet, based on the indications of the team coordinated by the Down Movement and formed by the researchers Márcia Denise Pletsch (UFRRJ), Patrícia Braun (UERJ), Márcia Marin (Colégio Pedro II), Talita Matos (Down Movement) and Daniela Marçal (Down Movement).

- Pilot application (Figure 1) in 2016 by the UFRRJ team in a public school in a municipal network of Baixada Fluminense[8].

Figure 1 – Pilot application (November 2016)

Source: ObEE database (2016).

- Analysis and review of the accessible digital textbook prototype based on the universal design concept applied to learning by the multidisciplinary project team after the pilot application.
- Review and development of the prototype and software for the digital textbook accessible by the Computer Science team at UFRRJ.
- Systematic study, conducted by the Computer Science team at UFRRJ, to acquire the necessary equipment for the development of the project. A detailed description of this process can be found in the item "Technological aspects" of this report.

8 The detailed analysis of the prototype project was carried out by Souza (2018) in her Master's research.

- Selection of schools and participating subjects in the research to apply and evaluate the accessible digital book prototype. For that, it was necessary: a) to present the project to the participating municipal managers in the Forum, who then indicated schools, teachers and students who met the necessary criteria to participate in the project; b) conduct a seminar with managers and teachers to explain the theoretical-methodological proposal and formally establish the partnership. Schools from the municipal education networks of Belford Roxo, Nova Iguaçu, Mesquita and Duque de Caxias participated in the project.

Second phase – from 2016 to 2018

The second phase, developed by a multidisciplinary team formed by researchers from UFRRJ and UERJ[9], took place in schools located in different social contexts in Baixada Fluminense/RJ for the application and evaluation of the accessible digital textbook protocol from the UDL perspective. Qualitative research was carried out using different data collection instruments.

In this initial phase, we offer ongoing training to 200 Basic Education teachers (Figure 2), primarily from Baixada Fluminense, with a duration of 120 hours, involving topics such as technology, curriculum, teaching and learning processes for people with disabilities and UDL. It is worth explaining that as a final product for completing the course, the participants created a pedagogical object with a description of application in the classroom, focusing on a student they would work with. To encourage this, there was a competition with the most innovative objects. Of the more than twenty works presented, ten were chosen and awarded.

9 These researchers, in turn, coordinated teams made up of scholarship holders (undergraduate, master's and doctoral students and Basic Education teachers) selected through a public notice.

Figure 2 – Extension Course Images

The course was certified by the Pro-Rector of Extension at the Universidade Federal Rural do Rio de Janeiro (UFRRJ). The activities developed in this course were published in the second edition, in 2017, of the Special Education and Social Inclusion Newsletter, under the coordination of the researchers Patrícia Braun and Márcia Marin.

Source: ObEE database (2016).

Topics of the extension course "Teaching and Learning for Students with Disabilities: Curriculum Strategies and Technological Resources"

1. Political and theoretical dimensions of the teaching and learning processes of people with disabilities.
2. Curriculum differentiation and universal design of learning.
3. Collaborative proposals for research and pedagogical innovation.
4. Collaborative work strategies and theoretical assumptions about the schooling of people with visual impairment, intellectual disability, deafness and autism.
5. Workshop 1 - Teaching and learning: accessibility strategies and resources for people with deafness.
6. Workshop 2 - Teaching and learning: accessibility strategies and resources for people with intellectual disabilities.
7. Workshop 3 - Teaching and learning: accessibility strategies and resources for the visually impaired person.
8. Workshop 4 - Teaching and learning: accessibility strategies and resources for people with autism.
9. Collaborative Consulting: Moodle.
10. Closing Seminar and 2nd Exhibit of Inclusive Pedagogical Resources.

In turn, it was up to Souza (2018) to analyze the results of the questionnaires answered by teachers to assess their knowledge about school inclusion, teaching and learning processes for people with disabilities, curriculum accessibility, UDL and the use of technological resources. One of the main demands placed by the teachers in the encounters and activities of the course was the incorporation of students with autism and low vision in the project of the protocol for the accessibility of the digital textbook, an aspect that was met, as we will see later.

Third phase – from 2017 to 2018

In the third phase, four field research teams were organized under the supervision of the researchers, covering the following areas: intellectual disability, deafness, visual impairment (blindness and low vision) and autism. These teams participated in three internal seminars to deepen and align the theoretical-methodological aspects necessary for data collection. In this phase, the instruments for recording field data were also developed and evaluated. We use two structured instruments: the data record form and the protocol itself.

The first was completed by two observers in each application and the second was completed at the end of the applications by the team in each area (Annexes 2 and 3). All applications were also filmed and records were made in field notebooks by the research teams in each area. Although this is not the objective of the project, at the end of the applications, we conducted open interviews with teachers from the common teaching class and from the Specialized Educational Service (SES) to find out their opinion on the applicability, in the classroom, of the accessible digital textbook in the perspective of the UDL.

The application of the prototype (Figures 3 to 6) took place in two spaces for students with intellectual disabilities, autism and low vision: two in the common classroom and two in the SES, with two applications in each. This made it possible to assess different variables, such as interaction, participation, collaboration among peers and the responses given by the subjects individually and collectively with classmates.

Figure 3 – Application of the prototype by the intellectual disability team

Source: ObEE database (2018).

Figure 4 – Application of the prototype by the deaf team

Source: ObEE database (2018).

Figure 5 – Application of the prototype by the visually impaired team (blindness and low vision)

Source: ObEE database (2018).

Figure 6 – Application of the prototype by the autism team

Source: ObEE database (2018).

In the case of deaf students, as indicated by the National Policy on Special Education from the Perspective of Inclusive Education (BRASIL, 2008), the networks have been organized in schools and classes from the perspective of bilingualism. In this sense, the application of the prototype for the deaf took place in bilingual classes because they teach the Brazilian Sign Language (known by the anacronym LIBRAS) as their first language and written Portuguese as a second language. Therefore, applications for deaf students took place in bilingual classes and in the SES's multifunctional resource room.

In the case of blind students, most networks organize classrooms and polo schools so that they, at the beginning of their school career, have access to Braille and other assistive technology resources, and later they are forwarded to regular teaching schools. This strategy has been an alternative adopted by the networks to provide quality and access to assistive technology resources to blind students, since the region faces difficulties in hiring qualified human resources to work in different schools and is unable to acquire technological resources for various schools.

Before starting the applications in schools, we invited teachers and administrators to participate in a meeting on the dynamics of data collection. After completing the applications, to assess the results, we organized a set of data that were presented at a technical hearing[10] (Figure 7) on June 25, 2018, with the participation of 55 education professionals, researchers from the state of Rio de Janeiro and people with different disabilities.

Figure 7 – Moments of the Technical Hearing

Source: ObEE database (2018).

Based on the contributions arising from this technical hearing, we revised and organized the protocol, which was presented at a public hearing (Figure 8) on June 29, 2018, open to all of society, with the participation of approximately 150 professionals from Basic Education, Education Secretariats of seven schools of the Baixada Fluminense, managers of participating universities, researchers and people with different disabilities.

10 The list of participants and their roles can be found in “acknowledgments” at the end of this report.

Figure 8 – Public Hearing

Source: ObEE database (2018).

Research Subjects

Twenty-one students participated in the field research (5 with intellectual disabilities, 4 with autism, 4 with blindness, 4 with low vision and 4 deaf students), in addition to all of their classmates, teachers from regular classes and teachers from specialized educational services.

Table 1 below systematizes the data referring to the participating subjects. We inform that all names are fictitious to preserve the identity of the subjects, as indicated by the Research Ethics Committee involving the Human Sciences area.

Table 1 – Data on the participants of the research project

Students and age	Special Education Category	Teachers of the ordinary class (time in teaching)	SES Teachers (time in teaching)	Number of peers in class
André 7 years old	Low vision	Débora 21 years	Jane Not informed	30 students
Gabriel 10 years old	Low vision	Carla Not informed	Sonia 24 years	32 students
Kamilo 12 years old	Low vision	Érica 28 years	Paula 30 years	32 students
Tânia 7 years old	Low vision	Sheila 23 years	Liliane 16 years	32 students
Francisco 11 years old	Blindness	Ellen 7 years	--	7 students
Ana Flor 13 years old	Blindness	Marta 7 years	--	7 students
Ana Maria 8 years old	Blindness	Elaine 7 years	--	8 students
Carlos 8 years old	Blindness	Elaine 7 years	--	8 students
Pedro 10 years old	Deafness	Maria 32 years	Lena More than 20 years	5 students
Marcos 8 years old	Deafness	Fernanda 25 years	Lena More than 20 years	5 students
João 11 years old	Deafness and intellectual disability	Eliane 25 years	Margarete More than 20 years	5 students

Mateus 8 years old	Deafness	Eliane 25 years	Margarete More than 20 years	5 students
Otávio 7 years old	Intellectual disability	Anderson 8 years	Letícia 6 years	19 students
Leonardo 9 years old	Intellectual disability	Marília 25 years	Letícia 6 years	24 students
Lucas 8 years old	Intellectual disability	Kátia 6 years	Anderson 8 years	28 students
Luiz Bernardo 8 years old	Intellectual disability	Daniele 6 years	Letícia 6 years	28 students
Ana Carla 9 years old	Intellectual disability	Ana Not informed	Maria Not informed	18 students
Ana Paula 7 years old	Autism	Sandra 3 years	Silvia 23 years	14 students
Marcio 6 years old	Autism	Deise 27 years	Amélia 10 years	14 students
Anabela 7 years old	Autism	Sandra 3 years	Silvia 23 years	14 students
Caio 6 years old	Autism	Deise 27 years	Amélia 10 years	17 students
Total	21	21	17	

Source: Research data.

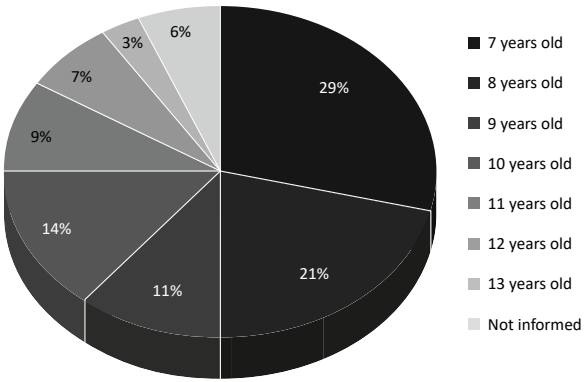
Qualitative analysis and production of statistics were carried out from the set of data collected in the field, at the technical hearing and at the public hearing.

Results

The results of the research project highlighted numerous questions about the context of the application of the accessible digital textbook from the perspective of the UDL, they also substantiated the analyzes on the UNICEF protocol used as a basis. *Such analyzes support the elaboration of the new final protocol presented in this report as one of the products of the project*. Below, we briefly present the results of the field research, based on which we were able to review and evaluate the accessible digital textbook protocol from the perspective of the UDL.

Of the participating subjects, 27% were made up of 13-year-old students, as shown in Chart 1 below.

Chart 1 – Age of the research participants



Source: Research data.

The average age of the students varied greatly: 31% were between 7 and 8 years old, 10% between 8 and 9 years old, 11% did not inform their age on the registration form and 48% were over 9 years old.

Considering that the research focused on the initial grades of schooling (1st to 5th grade), it is possible to affirm that part of the students is with an age-grade gap. Here, it is worth remembering that 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 last Basic Education Development Index (*Índice de Desenvolvimento da Educação Básica* – IDEB), released in 2018.

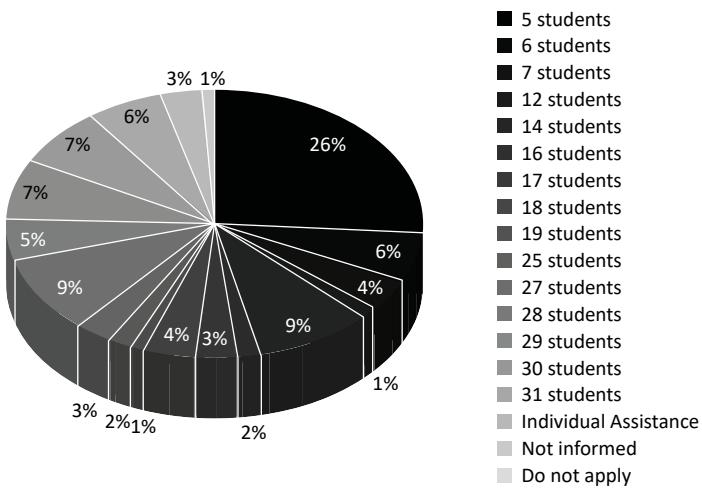
The number of students per class varied a lot, as shown in Chart 2. It is important to remember that classes for deaf and blind students have a smaller number, considering the specifics of the work developed in these classes already described in the methodology of this report. Still on the number of students in the classroom, in classes focused on autism, 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 regular schools in Brazil. However, in these classes there was more than one student with some specificity in their development, autism being one of them.

This fact can be understood from Bills that have already been approved that limit the number of students per class when there are students with autism, such as Bill no. 912/2011[11] and Law 15.830, of June 15, 2015[12], respectively of the states of Rio de Janeiro and São Paulo.

In this scenario, we observe the need to qualify the classroom space and the teaching and learning process that all students enrolled there are entitled to, because given the diversity of ways to learn that a class of students can present, to ensure a reasonable number of children in the classroom means ensuring that teaching strategies and resources can be better organized and offered to all.

Below, Chart 2 systematizes the data on students in the classroom.

Chart 2 – Number of students per class



Source: Research data.

11 Available at: http://mail.camara.rj.gov.br/APL/Legislativos/scpro0711.nsf/18c1dd68f96be3e7832566ec0018d833/99cb10f8113d0af98325786a0068552e?OpenDocument. Accessed on: September 20, 2018.

12 Available at: https://www.al.sp.gov.br/repositorio/legislacao/lei/2015/lei-15830-15.06.2015.html. Accessed on: September 20, 2018.

In order to analyze the various dimensions of the application of the accessible digital textbook in classrooms and in SES classes, we organized the results taking as principles the questions registered in the data registration form. We also made qualitative inferences using data recorded in the field diaries and the interviews with the teachers. Considering the enormous amount of data collected throughout the project, we made some analysis options to think about the possibilities of extensive use of the accessible digital textbook in educational networks. In the same way, we point out that further research and studies need to be carried out to improve the assessment of the impact of this resource in classroom contexts, as the focus of this project was to evaluate the protocol that inspired the development of the accessible digital textbook prototype.

In the first two questions of the data collection instrument, we analyzed the presentation of the digital textbook in the classes and its use by students at the beginning of the research. According to the data, the textbook was presented by the project teams to 61% of the students, 4% informed that there was a partial demonstration of the use of the book, 21% did not demonstrate how to use it before starting activities and 14% did not disclose this data in the registration form.

We also analyzed data regarding the strategies used to demonstrate the accessible digital textbook. As we verified, 55% used the strategy of delivering the tablet to students so that they could get used to the material by exploring resources with peers with mediation from researchers, 11% reported that they partially followed this strategy, 14% did not use this strategy, and 21% of the records did not provide this information.

Another data analyzed refers to the contextualization of the classroom content according to the school level in which the research was carried out and its connection with the activities proposed by the accessible digital textbook. According to field information, we found that 43% followed this connection, 37% did not follow, 2% partially followed, and 18% did not register this information. In this sense, a fact that drew a lot of attention from researchers refers to the appropriation of scientific concepts by students. To a large extent, classes in general, and not just students with a disability, showed weaknesses in basic concepts taught and learned in the early grades of Elementary School, such as the concept referring to the word ‘trunk’, as part of the human body, present in the digital textbook content.

On the acceptance of students to use the accessible digital textbook, we systematize the data on Table 2 below.

Table 2 – Acceptance, engagement and familiarity of students with the tablet

	Yes	No	Partially	Not informed
Student accepted the proposal developed using the digital textbook	67%	3%	16%	14%
Student was familiar with the tablet	47%	12%	27%	14%
Student performed the proposed activity with engagement and involvement	51%	14%	20%	14%

Source: Research data.

We also analyzed how students interacted and handled the accessible digital textbook (tablet), whether they needed mediation from researchers or teachers, whether they used the book with support/mediation or not from other resources/pedagogical objects. With regard to turning the tablet on/off, 46% of the students demanded constant mediation from researchers, teachers and classmates; 4% demanded partial mediation; 9% performed this activity without mediation; and, in 41% of the records, it was not possible to assess this variable due to the dynamics of the classroom.

We verified similar data in the item "the student selects the activity in the accessible digital textbook (tablet)". Of the total number of participants, 72% required mediation and support from classmates, teachers or researchers to select the proposed activity, 1% required partial mediation, 6% had autonomy to perform the activity selection, and in 21% of the records it was not possible to evaluate this item.

Another item that we evaluated concerns the students' ability to locate information in the task statement and carry out the activity. In this regard, we found that 39% demanded mediation and partial support from classmates,

researchers or teachers, 35% demanded constant mediation to locate the task in the textbook, and only 4% performed the activity independently after finding the information in the statement. It was only possible to verify this data in 21% of the records. Regarding the comprehension of the task statement, the data revealed that the majority demanded constant and partial support and mediation (34% and 37%, respectively) to understand the tasks to be performed. Only 5% had autonomy to read and interpret the statements. In 24% of cases, it was not possible to evaluate this category.

One of the central aspects in the research results concerns the mediation item. We initially analyzed mediation demands to seek alternative resources by students to understand the task, such as support links. We also verified the attitude of students towards the questions raised by teachers or researchers. The data show that mediation, as in the previous items, was the main aspect so that students could seek support from other resources and place themselves in the group about the questions asked by the teachers. For example, to search for resources on alternative links, 39% demanded constant mediation from teachers, classmates and researchers, 26% needed partial mediation, and only 8% managed to carry out the search independently. In 27% of the cases, it was not possible to assess this variable. With regard to participation in activities, providing answers to questions and questions asked by teachers or researchers, only 6% performed this task with autonomy without mediation, 25% demanded mediation from teachers and researchers, including giving examples from the daily lives of the subjects so they could understand the requests, 34% of the students needed partial mediation. In 35% of the cases, it was not possible to evaluate this information, based on the records made in the field observation form.

It is interesting to note that deaf students sought the activities in an errant way, that is, they performed the activities as they understood them, without necessarily having understood what was announced. This fact was noticed when the teacher performed the mediation with the content and such action changed the way students interact with the content and activities. This situation drew attention, as there was a window with sign language for each task statement, which at first was considered sufficient for deaf students to understand the content. However, due to the delay in the acquisition of sign language, as well as the difficulty in understanding academic content through sign language, other support resources were also needed, such as the use of

images and icons, as well as extra pedagogical resources/objects available in classroom, which were used through the mediation of the teachers.

It is important to mention that, in the case of deafness, we had to carry out a study on the possibilities of accessing the textbook using the Brazilian Sign Language (LIBRAS)[13] based on the references of the Pedagogy of Image[14] (SOUZA; CALIXTO, 2017), thus ensuring content that is actually accessible for deaf subjects without the mere translation into LIBRAS, as it is commonly done in textbooks that already exist in Brazil. This procedure makes our protocol original and innovative. It is worth mentioning that there is little or no research on accessibility in textbooks for people with intellectual disabilities, autism and low vision. In this sense, the protocol, product of this project, for presenting a set of technological and pedagogical possibilities, is certainly an important scientific and social contribution.

During the entire application of the prototype, it became evident that the use of pedagogical resources/objects complementary to the use of accessible digital textbook were necessary, such as, counting blocks, concept and idea maps, miniature objects, mirrors, puppets, shape sorting games, hygiene items (such as toothbrush, soap and others illustrated in the book) (Figure 9). We found that 20% and 28% of students, respectively, demanded the partial or constant use of these resources/objects to understand the contents/concepts covered in the activities presented in the digital textbook.

13 Law no. 10,436, of April 24, 2002 (BRASIL, 2002).

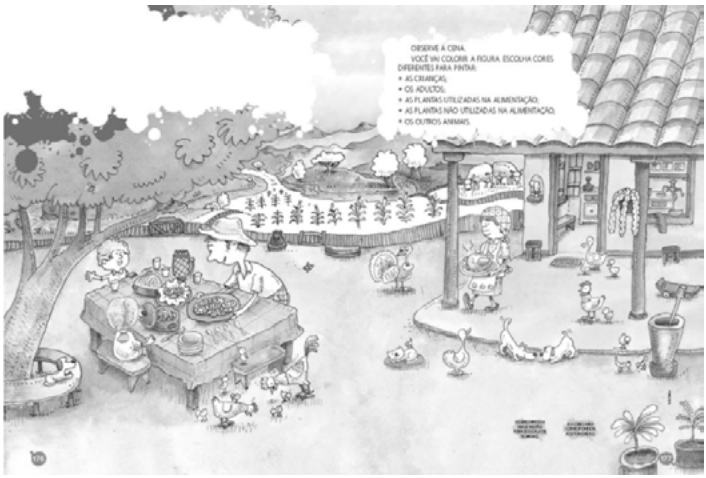
14 According to a parallel study carried out by the deaf team during the development of this project to ensure the Portuguese-Libras translation process used in the digital textbook.

Figure 9 – Low-tech teaching resources

Source: ObEE database (2016).

In the case of blind students (in this research, all with congenital blindness), as they were at the beginning of the literacy process, the use of miniature objects and resources was essential, without which the contents and concepts covered in the textbook would not have been learned. This is due to the fact that most are in the process of constructing the symbolic representation of the concepts covered in the activities proposed by the book. To illustrate, we can highlight the representation of animals and plants at the beginning of the book, as shown in Figure 10 below.

Figure 10 – Accessible digital textbook home screen interface



Source: Accessible digital book (2018).

As verified in the field research, blind students had no representation of what these animals were like without the use of miniatures and without feeling them through touch. Still on the symbolic construction, our field diary records made it clear that the use of the digital textbook (with audio description features) and the objects/pedagogical resources in miniature, without the proper mediation of the teacher and, in some cases, the researchers, it would not be enough for blind students to understand more abstract concepts[15]. Equally, in the case of students with autism and intellectual disability, due to the specificities they present with regard to abstraction and generalization, the mediation of the teacher or researchers was essential so that the activities and concepts could be understood by the students.

For students with autism, in the case of two of them, both boys, for example, they accessed various activities in the digital textbook, but in the absence of a teacher's mediation, the engagement and use of the presented concepts

15 We highlight that it would be important to apply the accessible digital textbook also to people who have acquired blindness, as, according to studies carried out, there is a difference in the symbolic construction of concepts between congenitally blind people and people who have acquired blindness. In Brazil, one of these studies was carried out by Pitano and Noal (2018).

weakened or acquired less sense and meaning. In the case of the two girls with autism, despite showing engagement in the activity, they had little familiarity with the use of the tablet, being the mediation of a teacher to help operate certain aspects (such as connecting, accessing the activity, accessing links or even page scrolling) essential for them to have some kind of approach to it. In particular, mediation and use of resources with the girls were essential given the specificity of the time of engagement, level of attention, form of understanding the established dialogue and concepts covered in the activity. The role and importance of mediation with students with autism has also been highlighted in other pieces of research (MACÊDO; NUNES, 2016; RAMOS *et al*., 2018).

In the case of subjects with intellectual disabilities, several studies (ABREU, 2006; ALMEIDA, 2016; AVILA, 2015; BRAUN, 2012; CAMPOS, 2016; CATHCART, 2011; HOSTINS; JORDÃO, 2015; LIMA, 2017; MENDES, 2016; OLIVEIRA, 2016; PLETSCH; MENDES; HOSTINS, 2015; SILVA; 2016; SOUZA, 2013; TRETIN, 2018) have shown the fundamental role of mediation for their schooling.

Some of these studies have even highlighted mediation as a central aspect, in addition to the pedagogical resources available in the classroom. Thus, the most important thing is not the resource itself, but the use that the teacher makes of this resource in their practice and intervention with students. Still on the use of pedagogical resources/objects, the data showed that only 7% of the participating students performed the tasks without using them, and 58% used them in some activities and not others, according to the demands and difficulties in appropriating the scientific concepts addressed in the digital book.

The last two aspects analyzed refer to the students' knowledge about the contents/themes worked with the use of the digital textbook and the relationship they made of it with their daily lives. About these results, based on the proposal to use accessible digital textbooks, we analyzed that only 6% of the students had knowledge about the requested content, and 9% were able to relate such knowledge to their daily lives. Thirty-seven percent of the students were able to express their views on the content, based on pedagogical mediations carried out by the teachers or researchers with examples, but only 22% were able to relate them to their daily lives.

The data also revealed that 25% of the students demanded more directive mediations with the use of several examples to understand the content/concept worked. Of these, 23% were able, after mediation, to relate the contents and concepts to their daily lives. In 32% of the participants, it was not possible to assess whether or not there was an appropriation of the contents/content worked, based on field records. Equally, in 46% of the cases, the data did not allow us to assess the relationship made by the students with the contents and concepts of work in their daily lives, that is, socially applied to routine life tasks.

In the field of research with deaf students who also live in poverty, there was a mismatch between the routine content of daily life, which was in the textbook used for the development of the prototype, in relation to the daily lives of the students. For example: one of the students did not consider the 'bath' activity as a daily activity; another student had difficulty recognizing the meal that is eaten at night, as there is no dinner at home. This fact points out that, in addition to the consistency of technological devices, the content of an accessible digital textbook must be thought of based on the objective reality of the lives of students who will use it as a central pedagogical resource in their school activities.

Based on these data, it is possible to infer that the pedagogical mediation of teachers proved to be essential for students to not only handle and use the digital textbook accessible on a tablet, but also that, without mediation (partial or constant), most of the students would not have benefited from the pedagogical resource in accessible digital format from the perspective of universal design. In this sense, the research highlighted the three aspects explained below.

The first aspect: *without teacher mediation, there is no effective teaching*, hence the need to collectively build pedagogical actions in which teachers recognize themselves as drivers of the educational development of children and young people in their classrooms. The second: *the students participating in the project are not digital natives*, as is commonly repeated in scientific literature and in the media, but they are inserted in social contexts in which technology is present, mainly through the use of cell phones. The survey showed that a significant part had never handled a tablet, however, many knew how to use technological resources present in the textbook, such as zooming something to see it better, looking for icons to command an action, or scrolling the presentation on the screen in a curious

and intuitive way, looking for new things. It is important to note that the research took place in classrooms in which observers were repeatedly asked to assist students with the tablet and, as a result, it was not always possible to properly register the interaction among the subjects and between the subjects with the accessible digital textbook.

The third aspect refers to the *accessible digital textbook itself*, which is characterized as an attractive, dynamic tool that generates interest in the news and the variety of possibilities that allows the use of various resources — image, voice, video, sound and visual feedback, for example. However, it is important to clarify that it constitutes *one more resource*, just like so many others, that can be used in the classroom to ensure effective teaching and learning for all students, regardless of the specifics in the development that each one may present, as it is the case of the Special Education population, thus expanding the possibilities of educational and, consequently, social inclusion.

Based on these results, *we evaluated the UNICEF protocol and restructured it with a series of technological and pedagogical recommendations*, in order to guarantee accessibility to digital textbooks, in accordance with the principles of the UDL. Before we present the final version of the protocol, it should be said that, for the guidelines to be prepared by publishers for the use of accessible digital textbooks by teachers, indications and examples on the use of the digital textbook in collaboration with other resources/teaching objects must be necessarily inserted. Such examples could follow those already developed by eLABorando, in partnership with the Rodrigo Mendes Institute and the Down Movement, published on the Diversa website[16]. There, it is possible to find a set of accessible pedagogical resources produced with low-cost material used in classroom contexts.

16 Available at: http://diversa.org.br/materiais-pedagogicos/. Accessed on: September 25, 2018.

Protocol for the accessible digital textbook after application, evaluation and restructuring

Final protocol[17]

MANDATORY REQUIREMENTS				
FEATURES/DISABILITIES	**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		

17 Elaborated by researchers Márcia Denise Pletsch, Patricia Braun, Marcia Marin and Flávia Faissal de Souza (2018).

Standard font The standard font should be *sans SERIFA*, in bold and block capitals: 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 also be 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 (AAC) 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 (AAC), 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, being: 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 where 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 **Navigation with highlighted 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

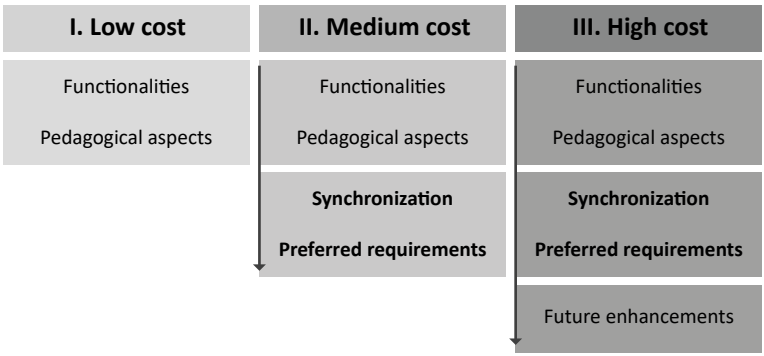
Text highlighting by touching or by moving the cursor via mouse The feature to highlight all text in the textbook (through colors and sounds) must be available when the user browses (or searches, hovers the cursor) with the mouse or finger over the textbook.	x	x	x	x
Narration (text to speech) The content 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 (AAC). 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 mm by 9 mm. There must be a distance of at least 1 cm between one icon and another 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**

The protocol can be applied to digital textbooks in three formats with different cost structure and complexity: a) with low cost, it would only encompass a set of basic functions; b) with medium cost, it would encompass the functions present in the previous item and new functions with greater interaction with the user; c) with high cost, it would cover all the previous functions and also present technological improvements of total user interface with the system. The following scheme systematizes the protocol based on these three formats.



Technological aspects in the production of the accessible digital textbook prototype[18]

The digital textbook is designed to be presented to students on a tablet. Initially, the EPUB3 format (TOSHIYA; SHUM; TAMURA, 2013) was chosen for the development of the prototype. Natálio and Bidarra's (2014) work mentions that EPUB has been the frequently adopted standard as a format for e-books, and that they were limited, until recently, to being static replicas of printed books. According to these authors, the publication of the EPUB3 specification significantly increased the capabilities of the format, in order to better support a wide range of publishing requirements, including complex models, multimedia, interactivity and the use of typography as a creative process.

In addition, there are several applications capable of reading books that follow this specification. However, after a careful analysis of the main apps of the type existing in the App stores of the Android platform, we verified that none of them offered the possibility to execute JavaScript code, eliminating the opportunity of children's interaction with the book when performing the

18 This item was elaborated by Professor Luis Fernando Orlens, Ph.D, Technological Coordinator of the Project.

exercises. As it is basically a web page (using HTML language) with images, videos, code snippets using the JavaScript programming language, among others, it should be possible to use it on any device that offers a web browser, such as conventional computers, smartphones, etc.

The presence of mobile devices such as laptops and tablets in the daily life of the classroom also brings into play the verticalization of knowledge centered in a special way on the teacher, on the textbook, on research in printed material, as the instant access to information allowed by these devices confront this historical hegemony of the teacher's attributions, enabling a more horizontal relationship between teacher, student and knowledge (SONDERMANN; ALBERNAZ; BALDO, 2013). In our understanding, the teacher can use the tablet to prepare classes, access the internet during contact with the student, encourage research, read digital books, consult available content, among others.

However, it is very important to know which tablet to use and its technical specifications to get the most out of the device. Information such as tablet model, RAM speed, storage capacity and screen resolution are all critical. For example, in our project we had to use a tablet that would allow the use of digital books without internet access, since most schools do not have internet access in the classroom.

To choose the tablet models, a conservative approach was adopted: thinking about how the application sessions would be carried out with the children, where unforeseen events can happen, and, due to that, it is not possible for a computer specialist to be present in all locations at the same time, it was decided that the tablets should have the Windows 10 operating system, familiar to everyone on the teaching team who would be in the application sessions. Thus, 50 tablets were tendered with the following characteristics to be distributed to the teaching team: Intel Atom processor with 4 cores, 2GB Memory RAM, 64GB SSD storage, Wi-Fi, Bluetooth, 8-inch capacitive screen and high-speaker.

The chosen students in schools for the applications were previously inserted in the textbook's source code so that it was possible to select them, and the display was automatically adjusted. However, as there was the possibility of other children using the textbook at the time of application, the registration of new students was allowed. The identification of who uses the textbook was necessary to allow the collection of usage data. Each student has information

in the system such as: name, applicator, school, disability(ies) and a list containing details of each response that the student produced during the session. The details of the answers will be attached to an object using the JavaScript programming language. These details are described by: question number, text with the answer chosen by the student and date of the answer. All answers are stored in a vector of response objects. A session is described as a period starting from the identification of the student until the beginning of an identification of a new student.

At the end of a session, an object receives all the information generated during the session process, and is registered in an object offered by the HTML5 specification, called Web Storage, whose main function is to allow the storage of a user's data on his/her own machine, being an alternative to the use of cookies.

The object can be sent at any time to the server if the applicator wishes; if the applicator chooses not to send the object or even not to send it due to problems with the internet connection, the object will already be saved locally (that is, on the tablet) in the Web Storage object, being able to carry out new book applications without losing previously collected information.

Based on the idea of Universal Design, the digital textbook proposes to be a "unified" application, that is, according to the specificities of each user, the textbook must behave in a way that overcomes the problems without becoming too specific, allowing a use accessible to any user. As the project deals with school learning, the main issue is the various disabilities that can influence learning performance, so the aim is to make the textbook an instrument fully accessible to the weaknesses selected as the target of the research.

One of the disabilities studied was hearing impairment, whose most serious diagnosis is deafness with total hearing loss. It is necessary for the student to be able to interpret texts and audios through an alternative language that is more appropriate for deafness, so videos were created that translated the texts into the Brazilian Sign Language (LIBRAS), as seen in Figure 13. However, for students with low vision, buttons were added that activate ("touch") the audio descriptions, which serve to narrate texts and images. Nonetheless, that alone is not enough, as it is also necessary to deal with people with partial vision loss. Thus, it was essential to build a layout that contained a different light level and color than the default layout, in order

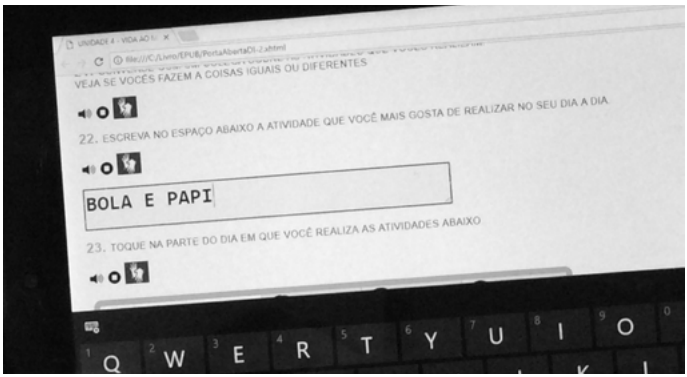
to increase the contrast between the background and the letters and, consequently, the readability.

Figura 12 – Example of subtitles in LIBRAS

Source: Screen print.

Figure 13 shows how accessibility buttons were allocated in the book to activate subtitles in LIBRAS and audio descriptions.

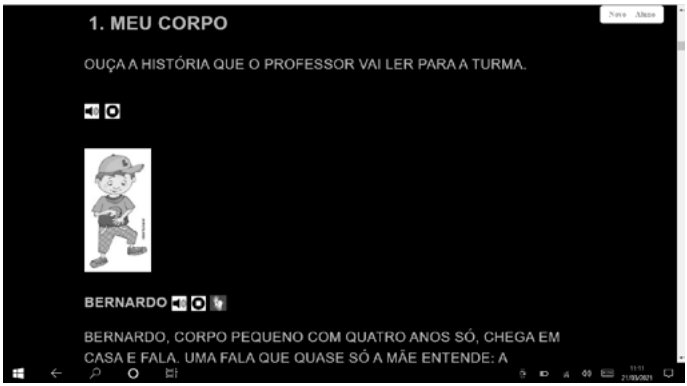
Figura 13 – Location of accessibility buttons



Source: Screen print.

However, by selecting the low vision option, as stated earlier, the textbook automatically adjusts its display, as shown in Figure 14.

Figure 14 – Textbook set for students with low vision: black background and large yellow letters to increase contrast

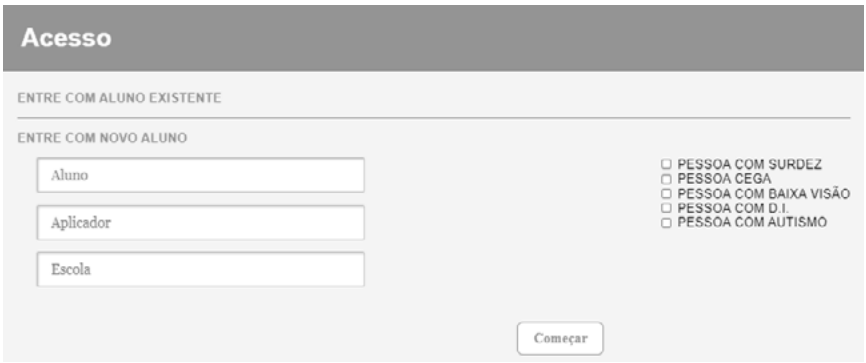


Source: Screen print.

One of the proposals of the project is to collect data from each iteration, that is, the textbook is composed of several questions as shown in Figure 15, where a selection box is presented with 9 figures from 3 different genres (plants, animals, people). In addition to the selection box, the figure also presents another box where the figures will be stored according to their gender. The book stores each informed answer, whether it is correct or incorrect; in this way, for future work, it will be possible to analyze the percentage of correct answers for each student, as well as identify patterns of use. By doing so, it is possible to identify the content (text and/or questions) where the textbook users have more difficulty and look for ways to improve the material.

Data for each student is collected as soon as the book is "opened" (that is, when a session starts), as shown in Figure 15. This data consists of: student name, book applicator, the school where the application is taking place, and the specifics of that student. All this data is saved in the textbook section and, later, with the help of the Internet, sent to a database.

Figure 15 – Textbook start screen



Source: Screen print.
Obs.: By selecting the specificity, the book adapts to it.

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List of annexes

Annex 1 –UNICEF protocol used as an initial instrument to apply and evaluate the accessible digital textbook from the perspective of the UDL

Features/ Disability	Blind and low vision	Deaf and hard of hearing	Intellectual and developmental disabilities	Learning disabilities	Motor disabilities
Mandatory requirements					
All functionalities should provide the options to turn on and off (sounds, audio, moving objects, video, etc.)	X	X	X	X	X
Portrait orientation: the screen orientation of the book must be available in both Portrait and Landscape. When selected in the menu, the preferred screen orientation should always remain the same to avoid confusion and disorientation.	X	X	X	X	X
Subtitles: all audio recording and video must have subtitles in local language and be synchronized with the referring text.		X	X	X	
Highlighting: The text must be highlighted when the user browses the mouse or the finger on it.	X		X	X	

Media or visual support: the software must allow pictures, images, graphics, and videos to be inserted.	X	X	X	X	X
Narration (text to speech): A narration of all the text in the book must be available, including headings, page number, paragraphs, titles, and references. The text must be synchronized with the narration. Ideally, the recording should be done by human voices, with local accent and vocabulary.	X		X	X	X
Vibration feedback: Vibration feedback must be available to acknowledge a command given by the user, possibly for an operation, such as an answer or the confirmation that a key has been pressed on the screen, or a feedback prompting the end of an action.	X	X	X	X	X
Audible feedback: Audible feedback must be available to acknowledge a command given by the user, possibly for an operation, such as an answer or the confirmation that a key has been pressed on the screen, or a feedback prompting the end of an action.	X		X	X	X

Audio-description: Audio-description must be available for the user to access description when required, such as for images, pictures or graphs. Ideally, the recording has to be done by human voices, with local accent and vocabulary.	**X**		**X**	**X**	**X**
Drag and touch functions: the screen must have an option that enable the touch element to work. The user should be able to drag a finger around the interface and hear the content of the screen (with or without vibration). The user should also be able to point/click without dragging.		**X**	**X**	**X**	**X**
Adjustable orientation of the video: 4 orientations - Up, Down, Right, Left- should be available in the settings.			**X**	**X**	**X**
Adjustable size of video: 3 sizes of the window- Small, Medium, Large- should be available in the settings.			**X**	**X**	**X**
Subtitles for deaf and hard of hearing: all audio and video must be completed by subtitles for deaf and hard of hearing in local sign language.		**X**			

Synchronization					
Synchronized video with Sign language interpreter: a video of a local SL teacher/ interpreter that signs the content of the text or the activities in local sign language, with voice-over and subtitles (both with option to be visible or not) must be included next to the corresponding text, word, image or paragraph.		**X**			
Synchronized video: a video synchronized with the text, the image, the exercise or the graph must be available next to the corresponding reference. The size and the positioning of the window on the screen should be adjustable. Subtitles in local language should be part of the video (so it moves together with the video).		**X**	**X**	**X**	**X**
Synchronized narration: The narration must be synchronized with the text for the headings, page number, paragraphs, titles, and references. The audio-description should be synchronized with headings, page number, table of content, glossary, images, videos, graphs, exercises, and references.	**X**		**X**	**X**	**X**

Menu: all adaptations must be provided in a menu where the user can choose his preferences and create a profile that stores these information. The menu should have an optional sound, vibrations, sign language video and voice feedback.	X	X	X	X	X
Navigation: the navigation within the document must be facilitated with tagging. The text must be tagged with the structure of the book, including headings, page number, table of content, glossary, images, videos, graphs, exercises, and references.	X	X	X	X	X
Glossary: The textbook must have a glossary with the definitions presented with the option of text, icon/symbol, audio, narration of the word, phonetic spelling and sign language video.	X	X	X	X	X
Text adjustment: Adaptable fonts, changeable colors, background contrast, line spacing, space between words, simple uncluttered layout with zoom functions are all attributes that must be available to make it more usable.	X		X	X	X

Preferred requirements					
Standard size of interactive items: all interactive buttons, images or icons should be at least 9mm by 9mm. All touch targets should be surrounded by an inactive space in a contrasting color.	**X**		**X**	**X**	**X**
Control of speed of interactive features: the user should be able to adjust the speed of all interactive features such as videos and screen elements.	**X**	**X**	**X**	**X**	**X**
Electronic memory: The software should be able to store the information such as preferences and layout, answers on exercises, and mark where the student has last opened the book.	**X**	**X**	**X**	**X**	**X**
Future enhancements					
Interactive support: the software should allow interactive inputs.	**X**	**X**	**X**	**X**	**X**
Voice recognition: The software should allow voice recognition which converts spoken words into typed text.	**X**		**X**	**X**	**X**

Annex 2 – Data Collection Instrument - Recording and monitoring form of observations – Field research

Guidance and clarification

- During each application, that is, at each use of the tablet in the classroom or in the resources room, two observers/applicators will be required to carry out the notes and records. Then there will be peer review for validation.
- At the end of this form, there is space for field notes and for recording a brief description of the school context and how the dynamics between the research target student and their peers in the classroom happened, as well as the dynamics between him/her and the teacher while using the tablet.
- The answers given by each student who used the tablet are stored to be later deposited into a database, as research material. For this function to be performed, it is necessary that each use of the tablet always has a finalization and then start with a new student. This "new" student may be someone who has already started an activity and has not completed it, as it will resume where it left off.

Date: ___/___/_____

Observation starting time: _____

and ending time: _____

Observer: _____

School: _____

City: _____

Student: _____

Class/MRR: _____

Teacher: _____

Gender: _____

Age: _____

Disability: _____

Schooling time at this institution: ( ) 1 year ( ) 2 years ( ) 3 years ( ) 4 years ( ) more – How many? _____

Is there a history of school retention? ( ) yes ( ) no

In which school grade? _____

Number of students in the class: _____

Average age of students in the class: ( ) 6 to 7 years old ( ) 7 to 8 years old ( ) 8 to 9 years old ( ) over 9 years old

INSERTION OF THE DIGITAL TEXTBOOK			
OBSERVED	**YES**	**NO**	**PARTIALLY**
The presentation of the DIGITAL TEXTBOOK was:			
• with a demonstration?			
• without a demonstration and free to use?			
• with peer exploration with teaching support?			
• with peer exploration with no teaching support?			
Contextualization			
Was there a relationship between the content developed in the classroom or in the school year and the proposed activity with the *digital textbook*?			
The **acceptance by the student** of the pedagogical object and the proposal was marked by:			
• interest?			
• familiarity?			

• strangeness?			
• engagement (involvement in the activity)?			
• repulsion?			

ACCESSIBILITY PROTOTYPE					
OBSERVED IN STUDENT HANDLING	WITH CONSTANT MEDIATION		WITH PARTIAL MEDIATION		NO TEACHER OR PEER MEDIATION (WITH INDEPENDENCE)
	TEACHER	PEERS	TEACHER	PEERS	
Turns on the tablet					
Selects the activity					
Finds information to perform the activity					
Understands the task and starts it					
Carries out the activity					
Selects links to support his/her need to carry out the activity					
From use and with any form of language:					
Participates in the debate about the activity					
Carries out the activity using auxiliary teaching objects/resources					
Carries out the activity with no use of auxiliary teaching objects/resources					
Uses specific concepts related to the theme					

Relates facts of his/her daily life with the content being dealt with					
Presents knowledge about the content being dealt with (learning)					

Field diary records

Annex 3 – Protocols filled in by the teams in each area at the end of the applications

ACCESSIBILITY AND FEATURES RECORD FORM BASED ON THE UNICEF PROTOCOL FOR STUDENTS WITH INTELLECTUAL DISABILITIES AND AUTISM

FEATURES	YES	NO
All features provide on/off options (sounds, audio, moving objects, video, etc.).		
Portrait orientation: The screen orientation of the book is available in portrait and landscape format. When selected in the menu, the preferred screen orientation remains the same to avoid confusion and disorientation.		
Highlighting: Text can be highlighted when the user navigates (or browses, hovers the cursor) with the mouse or finger.		
Media or visual support: The software allows the insertion of photos, images, graphics and videos.		
Narration (text to speech): The text of the book is available in narration format, including headings, page numbers, paragraphs, titles and references. The narration is synchronized with the text (Ideally, the recording is done by human voices, with local vocabulary and accent).		
Audible feedback: Audible feedback is available to inform of 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.		
Audio description: The audio description is available to the user, when necessary, to access information available in the textbook, such as: images, photographs or graphics. (Ideally, the recording is done by human voices, with local vocabulary and accent).		

Drag and touch functions: The screen allows to work on the textbook by touch. That is, it is possible that the user can interact by dragging 'elements' of the interface with his/her finger and listening to the screen content (with or with no vibration). User is able to point/click without dragging.		
Adjustable video orientations: Four orientations - up, down, right, left - are available in the settings		
Adjustable video size: Three sizes of the window – small, medium, large – are available in the settings.		
SYNCHRONIZATION		
Synchronized video: A video synchronized with the text, image, exercise or graph is available next to the corresponding reference. The size and positioning of the window on the screen is adjustable. Subtitles in the local language are part of the video (may move along with the video).		
Synchronized narration: The narration is synchronized with the text for the headings, page numbers, paragraphs, titles and references. Audio description is synchronized with headings, page numbers, table of contents, glossary, images, videos, graphs, exercises and references.		
Menu: All adaptations are provided in a menu from which the user can choose his/her preferences and create a profile that stores this information. The menu has optional sound, vibration and voice feedback.		
Navigation: Navigation within the document is facilitated with tagging: there is a text marker linked to the structure of the book, including headings, page numbers, table of contents, glossary, images, videos, graphs, exercises and references.		
Glossary: The textbook has a glossary of definitions presented with the option in text, icon/symbol, audio, narration of the word, phonetic spelling and sign language video.		

Text adjustment: There are adaptable fonts, changeable colors, background contrast, line spacing, spacing between words and simply organized layout with zoom functions as attributes available to user accessibility.		
PREFERRED REQUIREMENTS		
Standard size of interactive items: All interactive buttons, images or icons are at least 9 mm by 9 mm.		
Speed control of interactive features: There is the possibility for the user to adjust the speed of all interactive features, such as: videos and screen elements.		
Electronic memory: The software is capable of storing information such as preferences and layout, answers to exercises, and marks where the student last opened the textbook.		
FUTURE ENHANCEMENTS		
Interactive support: the software must allow interactive inputs.		
Voice recognition: The software must allow voice recognition that converts spoken words into typed text.		
SPECIFIC ITEMS		
Reading comprehension: There are resources to highlight, anticipate vocabulary, expressions that make it possible to understand the concept/content/subject covered in the text, image, graphic, enunciated by the user.		
Experimentation of concepts: There are suggestions for simulators, exercises, games with experimentation on concepts covered in the contents of the activities.		
Advanced organizers: There are resources available that contribute to the systematization of information/content/concepts presented in activities, such as: concept or mind maps, timelines, image glossary, word bank, infographics.		
Relation and analysis between/of concepts: There are resources to highlight or make explicit the relationship between ideas in a text, image, graphic, concept or mind map.		

User expression: There are resources that allow the exposition/expression of the student to answer, interact and present the execution of the activity using a varied language format: oral (recording the answer), making or using a video or drawing or chart/summary.		
Synchronization: The excerpts of the text, task question, caption, titles, alternatives, among other forms of written record are in evidence (with some emphasis) as they are spoken by narration.		
ILLUSTRATIONS:		
The illustrations used are simple, functional, containing only the elements that are significant to what is being dealt with in the activity/proposal.		
Subtitles are displayed next to the image that references them.		

ACCESSIBILITY AND FEATURES RECORD FORM BASED ON THE UNICEF PROTOCOL FOR BLIND OR LOW VISION STUDENTS

MANDATORY REQUIREMENTS **FEATURES**	**BLIND YES / NO**	**LOW VISION YES / NO**
All features provide on/off options (sounds, audio, moving objects, video, etc.).		
Portrait orientation: The screen orientation of the book is available in portrait and landscape format.		
When selected in the menu, the preferred screen orientation remains the same to avoid confusion and disorientation.		
Highlighting: Text can be highlighted when the user navigates (or browses, hovers the cursor) with the mouse or finger.		
Media or visual support: The software allows the insertion of photos, images, graphics and videos.		
The software allows interaction with other devices (tablets, cell phones) or its own applications.		

Narration (text to speech): The text of the book is available in narration format, including headings, page numbers, paragraphs, titles and references.		
The narration is synchronized with the text (for example: text illumination during narration).		
Ideally, the recording is done by human voices, with local vocabulary and accent).		
Tactile feedback by vibration: Vibration feedback is 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.		
Audible feedback: Audible feedback is 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.		
Audio description: The audio description is available to the user, when necessary, to access information available in the textbook, such as: images, photographs or graphics. (Ideally, the recording is done by human voices, with local vocabulary and accent).		
SYNCHRONIZATION		
Synchronized narration: The narration is synchronized with the text for the headings, page numbers, paragraphs, titles and references. Audio description is synchronized with headings, page numbers, table of contents, glossary, images, videos, graphs, exercises and references.		
Menu: All adaptations are provided in a menu from which the user can choose his/her preferences and create a profile that stores this information. The menu has optional sound, vibration and voice feedback.		

Navigation: Navigation within the document is facilitated with tagging: there is a text marker linked to the structure of the book, including headings, page numbers, table of contents, glossary, images, videos, graphs, exercises and references.		
Glossary: The textbook has a glossary of definitions presented with the option in text, icon/symbol, audio, narration of the word, phonetic spelling and sign language video.		
Text adjustment: There are adaptable fonts, changeable colors, background contrast, line spacing, spacing between words and simply organized layout with zoom functions as attributes available to user accessibility.		
PREFERRED REQUIREMENTS		
Standard size of interactive items: All interactive buttons, images or icons are at least 9 mm by 9 mm. All touch icons are surrounded by an inactive space in a contrasting color.		
Speed control of interactive features: There is the possibility for the user to adjust the speed of all interactive features, such as: videos and screen elements.		
Electronic memory: The software is capable of storing information such as preferences and layout, answers to exercises, and marks where the student last opened the textbook.		
FUTURE ENHANCEMENTS		
Interactive support: the software must allow interactive inputs.		
Voice recognition: The software must allow voice recognition that converts spoken words into typed text.		

SPECIFIC ITEMS		
Written font enlargement adaptable to the needs of each student, with 39 characters per line (significant spacing between characters) and 1.5 line spacing.		
Enlarged font up to 24, with 39 characters per line and 1.5 line spacing.		
Contrast between letters (others) and background in: yellow/black, white/black, yellow/blue (royal), white/dark green, etc.		
Font *sans SERIFA*, in bold and capital letter.		
Font type: ARIAL, TAHOMA or VERDANA.		
Adequacy of lighting on the tablet screen.		
Screen reader for statements, icons, etc. and audio description of images, drawings, videos with no sounds, etc.		
ILLUSTRATIONS		
The illustration outlines are well defined and in high contrast.		
The illustrations used are simple, functional, containing only the elements that are significant to what is being dealt with in the activity/proposal.		
Avoid using pastel shades that are not always noticed, giving the appearance of a stain. Use of well-defined colors, with uniform filling that visually demarcates the details of the illustration.		
Subtitles are displayed next to the image that references them.		
There is a delimitation of the field of illustration (it facilitates the understanding of the focus/subject/relation in question).		

ACCESSIBILITY AND FEATURES RECORD FORM BASED ON THE UNICEF PROTOCOL FOR DEAF STUDENTS

MANDATORY REQUIREMENTS
Features
On/Off function: The application must offer the possibility to activate and deactivate all its functions, including: sounds, audios, videos, moving objects and so on.
Permanence on the textbook: The software must have a command that keeps the book on screen, preventing the user from exiting the book when necessary.
Screen orientation: Screen orientation must be available in portrait and landscape. When selected from the menu, the preferred screen orientation can remain the same to avoid confusion and disorientation.
Touch and drag functions on the screen: The screen must allow to work on the textbook by touch. This attribute must enable: to interact by dragging 'elements' of the interface with the finger; listen to screen content (with or with no vibration); drag book elements by moving the finger across the screen; point/click without dragging.
Subtitles: All audio and video recordings must have subtitles in local language and grammar in local sign language, synchronized with the referring text.
Highlighting: Text must be highlighted when the user navigates (or browses, hovers the cursor) with the mouse or finger.
Media or visual support: The software must allow the insertion of photos, images, graphics and videos.
Tactile feedback 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.
Video with local sign language: There should be videos with a teacher or interpreter who signs the text content or activities in local sign language. The video must contain voice and subtitles (local language, sign language, sign language grammar, etc.), both with the option to be turned on and off.

Adjustable positioning of the video on screen: It must be available in the settings, for the user's choice, to move the video up, down, right and left. This feature should allow subtitles in local language and/or grammar in local sign language to move along with the video.
Adjustable video size: The size of the video window must be available in the settings for the user to choose from: small, medium or large.
Subtitles for the deaf: All audio and video materials must be accompanied by local language subtitles, sign language grammar, text highlighting, etc.
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.
Texts with symbols, images and sign language grammar: The texts in local written language must be adequate to the user's level of comprehension. When necessary, symbols and images should be used to support the text. The use of sign language grammar should be considered.
SYNCHRONIZATION
Menu: All adaptations are provided in a menu from which the user can choose his/her preferences and create a profile that stores this information. The menu has optional sound, vibration and optional voice feedback, for signaling the command provided.
Video window with sign language synchronized with the referring content: The video window with local sign language must be opened next to the related content (text, image, exercise or graphic), making it possible to follow the signed content with text in the local language. When the book 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.
Navigation with tagged content: A function that allows navigation within the document with content tagging must be available. The text must be tagged with the structure of the book, including headings, page numbers, table of contents, glossary, images, videos, graphs, exercises and references.
Glossary: The book must have a glossary with the definitions of the concepts presented with the option in text, icon/symbol, audio, narration of the word, phonetic spelling and video in local sign language and/or grammar in local sign language.

Text adjustment: Adaptable fonts, such as adjustable colors, background contrast, line spacing, space between words, and simply organized layout with zoom functions should be available to make the book more accessible.
ILLUSTRATIONS
Content of illustrations: The illustrations used must be simple and contextualized, containing only the elements that are significant to what is being dealt with in the activity/proposal.
Illustration subtitles: Subtitles must be displayed next to the image that references them.
PREFERRED REQUIREMENTS
Standard size of interactive items: All interactive buttons, images or icons must be at least 9 mm by 9 mm.
Speed control of interactive features: The user must be able to adjust the speed of all interactive features such as: narration, videos, local sign language screen elements.
Electronic memory: The software must be able to store information such as preferences and layout, to answer to exercises, and to mark where the student last opened the textbook. The software keeps the answers to the exercises recorded and visible on the screen; the software offers “resume button” feature to clear and restart responses.
FUTURE ENHANCEMENTS
Interactive support: the software must allow interactive inputs in varied language formats: oral, video, photography, drawing, chart/summary and others.
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.

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Secretaria de Educação de Mesquita
Secretaria de Educação de Duque de Caxias
Secretaria de Educação de Belford Roxo
Secretaria de Educação de São João de Meriti
Secretaria de Educação de Japeri

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