AlfaMateca: A Mathematical Literacy Application for the Visually Impaired

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ABSTRACT

Teaching mathematics for the visually impaired is a difficult task, especially when it is aimed at young students. Taking into account the current technologies, teachers can use various tools to assist them in this great challenge. Focusing on the mathematical literacy task, we present ALFAMATECA as a computational tool for assisting the educational process. ALFAMATECA is specially designed for the use with young visually impaired students, assisting the process of mathematical literacy adopting some concepts of gamification.
As a result, ALFAMATECA is a free and scalable software, which is specifically designed for supporting the mathematical education of visually impaired students in an enjoyable and ludic tone.

Keywords: Mathematical Literacy, ALFAMATECA, software, visually impaired, inclusive education.

1. INTRODUCTION

According to Brazilian Institute of Geography and Statistics (IBGE), the 2010 Brazilian Census [1] shows that approximately 29 million Brazilians, or more than 13% of the total Brazilian population, had some kind of inability or disability. Of the aforementioned number, more than 6 million people have a severe visual impairment and more than 500 thousand people are blind.

According to Villela [2], among the types of disability studied, visual impairment is the most representative and covers 3.6% of all Brazilian population, being more common among people over 60 years (11.5%). For the population over 60 years, blindness or low vision makes it impossible for 16% of the visually impaired to perform their usual activities, such as working, using electronic appliances and performing daily tasks and domestic chores.

The introduction of assistive technologies in classrooms as inclusive proposals to assist the process of teaching and learning is, nowadays, especially supporting the mathematical literacy for visually impaired children. Assistive technologies are causing changes in the understanding and acceptance of disability problems by both schools and students. Assistive technology can be the main tool used by teachers to gather traditional teaching with technological advancement and supporting the educational process for all students.

The inclusion of special students is a right guaranteed by law in Brazil, and, has been discussed through both national and international documents, namely, *Brazilian Federal Constitution of 1988* [3], *Law of Guidelines and Bases of National Education* [4], *World Declaration on Education for All* [5], *Convention on the Rights of Persons with Disabilities– Legislative Decree No. 186/2008* [6], among others, regulating the inclusion of students with any type of disability in regular schools.
The works of Barreto and Fortunato [7] and Porto [8] analyze the use of software applications to support the visually impaired and shows how positive is their utilization. ALFAMATECA was developed addressing the problem of the lack of mathematical resources in computational environments oriented to visually impaired people, focusing initially on mathematical literacy in early grades. In this way, the ALFAMATECA tool was conceived with the purpose of supporting the mathematical education of visually impaired students, currently following the guidelines and activities of the book selected by the Brazilian National Textbook Program (PNLD) 2018, called *Apis Mathematical Literacy 1st/ 2nd and 3rd year*.

The aforementioned book was chosen due to its wide utilization among the Brazilian public schools, according to the National Development Fund for Education (FNDE). In the first year of the current triennial PNLD distribution (2016-2018), about 1.5 million copies of the *Apis Mathematical Literacy* books were delivered to the schools, being the most used material in the current triennium [9].

2. EDUCATION TOOLS FOR VISUALLY IMPAIRED CHILDREN

The literacy process of visually impaired students imposes on teachers the need to know the specificities of these students in order to adequate their educational planning and to avoid discomfort in relation to the other students.

According to Piaget's [10] research, it is possible to observe that the cognitive function of visually impaired children develops slower, comparing it with the development of the normal child. But learning happens in the same way, each child in their learning time.

The mathematical literacy of children, with or without disabilities, is a complex and sensitive task since it will be their first contact with numbers in an analytical manner,

therefore, it must be done in a harmonious and effective way. Focusing on more didactic and playful approaches, schools employ various materials to assist in this educational process, such as the use of books, videos, games, toys, and tools for teaching.

One example of a widely employed tool for teaching Mathematics to visually impaired children is the *soroban*, shown in Fig. 1. Also known as the *"Japanese abacus"*, it is a calculation tool developed in the 14th century and is still widely used in Japan for both educational and commercial applications [11].

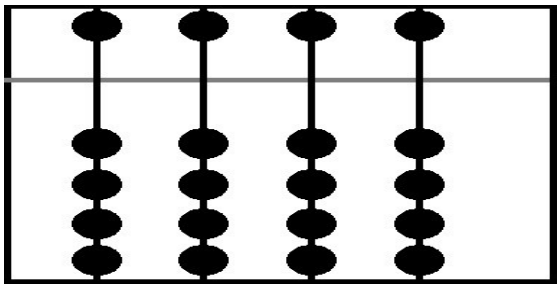

Fig. 1 – Soroban.

The soroban is an important educational tool for visually impaired children since it can be completely utilized with the hands and the somatosensory system for performing all four basic operations of arithmetic. Soroban is also a small tool, that can be carried in backpacks and can be easily built using inexpensive materials for both parents and teachers [12]. In Brazil, the Federal Ordinance No. 1.010 from May, 2006 states that soroban is "an essential asset for the execution of mathematical calculations for visually impaired students" [13].

Besides soroban, the *gold material*, created by Italian physician and educator Maria Montessori in the beginning of the 20th century, is also a widely used tool for teaching Mathematics to visually impaired students.

In recent years, new technologies, especially in form of computer software, are integrating the set of tools used for Mathematical education. Moran [14] states that, independently from the social context of a school, it needs to adapt its management to the reality of its community, i.e., the schools need to use the conventional educational tools and need to adopt the current technologies in their educational practices.

According to Moran [15], the integration of new media, *viz.* computer *hardware* and *software*, can improve the educational process and offer better for both professors and students. In this context, Prado [16] analyzes how the integration of new media is being made with unplanned use. According Prado [17], the use of new technologies must be preceded by sensible planning and analysis.

3. ALFAMATECA APPLICATION

This section defines the ALFAMATECA application in terms of the platform required for the use, functionalities, architecture and other technical information. As a working platform, ALFAMATECA uses two programs: DOSVOX (system that communicates with the user through a text-to-speech subsystem) and JOGAVOX (DOSVOX gaming tool). Developed by the Department of Electronic Computing of Federal University of Rio de Janeiro (NCE/UFRJ) [18], DOSVOX is a free operating system for personal computers (PC) that interacts with the user through the text-to- speech technology, which can be configured for different languages.

DOSVOX was developed aiming to facilitate and assist the visually impaired with a sensible use of computer interface and computer programming. In order understand the history of the creation of DOSVOX, it is necessary to analyze a problem that continues today, not only in the Federal University of Rio de Janeiro (UFRJ), but in all Brazilian universities: the low admission of visually impaired students in higher education and the fact that a few of those who are admitted are able to graduate.

As ALFAMATECA was designed for the use with young children, around 6 to 9 years, the lessons are presented in a way that is not only appropriate for their teachers and parents, they are focused in teaching Mathematics in an enjoyable and ludic tone. One of the *non-functional requirements* [19] implemented in ALFAMATECA in order to make it more suitable for young children [20] is the use of pre-recorded voices of children, as it was described as more "pleasant" than the use of speech synthesizer or some adult voices.

Fig. 2 – Home Screen of ALFAMATECA.

ALFAMATECA is available for download at Prof. Luiz César Martini (State University of Campinas) at: http://www.decom.fee.unicamp.br/~martini.

3.1 Utilization: ALFAMATECA architecture employs principles of *gamification* in order to provide a pleasant and functional *human-computer interaction* [21] for both the students and their teacher and family.

The lessons are divided into according to their subject in *menus*, as shown in Fig. 3, being easily accessed for both people with or without visual impairment as their description is automatically read by ALFAMATECA.

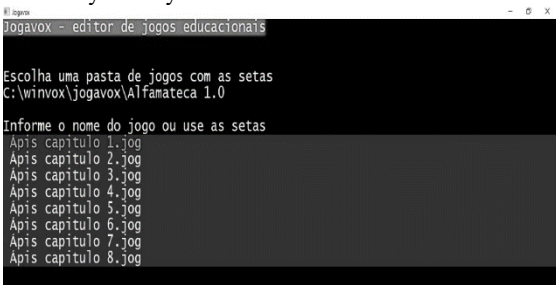

Fig. 3 – Menu presenting some chapters available in ALFAMATECA.

After selecting a lesson, its respective *script* containing the content of the subject and, especially, the statement and the *audio description* of the questions about the lesson. In order to provide a functional interface to sighted or partially sighted users, ALFAMATECA also presents the graphical elements related to the lessons and questions, as shown in Fig.4.

Fig. 4 – First Activity in ALFAMATECA.

Using principles of gamification to provide a ludic and interesting experience to the students, their answers have an immediate feedback in form of a voice message, giving different messages when the answer is correct or incorrect.

ALFAMATECA uses prerecorded voices of children, aiming to make the experience for visually impaired students more enjoyable and fun, since we believe that synthetic voices will make the class very tiring and discourage students. The exercises have a purpose of creating a playful and creative environment, where the student can find different challenges that are part of their daily life, making teaching more productive and motivating visually impaired children in joy of studying mathematics.

4. CONCLUSIONS, REMARKS AND FUTURE WORKS

The education process of visually impaired students is marked by the inherent relation with specialized assistance, which is a fundamental for the schools, families and the students. This specialized assistance must be provided by special education, either provided by schools or by the family, therefore, ALFAMATECA software was designed to support the education in the Mathematics field and to provide an additional tool for teaching visually impaired children.

ALFAMATECA currently has about 500 interactive questions related to the topics studied in the mathematical literacy process. In order to expand the ALFAMATECA utility and to keep support for the visually impaired students, we intend to continue the ALFAMATECA development in order to cover all the topics studied in the School years.

The authors would like to emphasize that, besides ALFAMATECA is being developed in Portuguese for the use in Brazilian Schools, we have total interest in translate it to other languages and to include the requirements of educational institutions of other countries.

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