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Virtual Reality Application for Students with Developmental Dyscalculia, Cerebral Palsy, or Visual Impairment: A Discussion on Accessibility Resources

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ABSTRACT
This theoretical article aims to discuss some accessibility resources and their implications in the use of a Virtual Reality application for Mathematics learning by Basic Education students diagnosed with Developmental Dyscalculia, Cerebral Palsy, or Visual Impairment. The application is under development, and through literature reviews, the most cited resources in national and international scientific productions that can directly influence the effectiveness of its conception and use are being identified. It presents resources for each specific need, highlighting mainly general aspects, among them: the visual part of the design layout needs to be discreet, considering color contrast; simple virtual commands are necessary, favoring students with motor coordination impairments; the use of sound resources and audio description, as well as haptic resources, can mitigate many motor and visual limitations.

Author Keywords
Application; Virtual Reality; Mathematics Learning; Special Educational Needs.

ACM Classification Keywords
H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities; H.5.2 [User Interfaces]: User-centered design; Graphical user interfaces (GUI); K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI); K.4.2 [Social Issues]: Assistive technologies for persons with disabilities; I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality.

INTRODUCTION
Technology has become essential in daily life, playing a crucial role in various areas and contributing to the improvement of quality of life. In the educational context, it has proven to be a valuable resource, allowing teachers to develop innovative and engaging activities for their students. This makes the learning process more engaging for the generation that was born immersed in the digital age.

Among these resources, immersive and non-immersive Virtual Reality (VR) applications stand out. When well-designed, these applications can be associated with resources that can mitigate some accessibility difficulties, particularly for students with Special Educational Needs (SENs). From this perspective, technology plays a role in accessibility and inclusion, as innovations can enable participation and exploration by everyone, regardless of their limitations and abilities [1].

Considering these issues, the Study and Research Group on Developmental Dyscalculia of the Pontifical Catholic University of Rio Grande do Sul (GEPEDPUCRS) has been developing studies since 2012 aimed at creating interventions that contribute to the learning of students with Developmental Dyscalculia (DD). In the last two years, this target audience has been expanded to other SENs, involving students diagnosed with Cerebral Palsy (CP) or Visual Impairment (VI).

Among the developed projects, two research projects stand out, which serve as umbrella projects. The first titled “Pedagogical Interventions for Students with Developmental Dyscalculia and Cerebral Palsy: Implications for Learning in Science and Mathematics”, with financial support from the Research Support Foundation of the State of Rio Grande do Sul (FAPERGS), and the second and the second, “Science and Mathematics Learning of Inclusion Students in Basic Education: Implications from the Design and Development of Mixed Reality Applications”, with funding from the National Council for Scientific and Technological Development (CNPq). The team is composed of master's and doctoral students in Education with degrees in Mathematics, and undergraduate research fellows from the Psychology and Computer Science courses.

Given that the intention is for the application to be used by teachers in the future to include all students in their class, it is justified to consider a common resource for students with certain educational needs, particularly those addressed in this research.

To guide the conception and development of this VR application, different data collection instruments are being used, which are fundamental for outlining the psychological and cognitive profile of the students participating in the research. A Systematic Literature Review (SLR) was also conducted on each of the SENs characterizing the students for whom the application is being directed, focusing on the use of resources aimed at accessibility. Based on the analysis of the results identified in the selected studies, this article presents an excerpt from the SLRs seeking convergences with the objective of discussing some accessibility resources and their implications in the use of VR applications for learning Mathematics by Basic Education students diagnosed with DD, CP, or VI.

Therefore, this article is structured in the following sections: The Use of Assistive Technologies for Inclusion Students; Some Special Educational Needs and Their Implications in Learning; Methodological Procedures; Virtual Reality Applications and Accessibility – Analysis of Results; Final Considerations.

THE USE OF ASSISTIVE TECHNOLOGIES FOR INCLUSION STUDENTS

Technologies can transform lives and make the world more accessible, especially for people with some disability. For this, according to Ferreira and collaborators [1], accessibility needs to be guaranteed during the design and development process of technological tools.

In the case of assistive technologies, Ferreira et al. [2] point out that the term encompasses services, objects, furniture, and pedagogical projects, with the purpose of assisting people with some type of disability. These technologies play the role of facilitating the participation of people with some disability in different daily and educational activities.

Currently, technology allows access to synthetic environments, immersive and high-definition types, capable of transporting us to alternative realities at low cost [3]. Virtual Reality (VR) was defined by Jerald [4] as "a computer-generated digital environment that can be experienced and interacted with as if that environment were real". The author [4] argues that an ideal VR system should allow users to walk around objects and touch them as if they were real.

According to Klinger, Sánchez, Sharkey, and Merrick [5], VR technologies provide users with a safe exploration environment, where they can develop guided activities, especially when these users have cognitive, behavioral problems, or even motor disabilities.

The idea of immersion "... refers to how precise a given computer system is in providing the user with the illusion of a reality different from the one in which they are" (our translation) [3]. In the case of the use of immersive VR in education, it can be said that it enables an interaction that goes beyond the real world, allowing the user a deep immersion in a virtual environment, even when these simulate places with difficulties of real access [6].

In this perspective, Afonso et al. [6] point out some factors that favor the use of VR in education, especially regarding immersive VR:

"... the students' motivation, the illustrative aspect that stands out over other media, the approach and distancing of the object, includes students with special needs, provides opportunities for experiences, allows the student to develop autonomy when studying, enables interaction and participation without affecting the development of the regular class" (our translation).

For Sánchez, Lumbreras, and Silva [7], VR allows experiences to be in the first person, which generates direct and subjective knowledge. Moreover, immersion allows interaction using language existing in the real world, providing the opportunity to experiment with concepts before formalism.

In all cases, the teacher's role is important as a mediator of teaching and learning processes and curator of materials.

Especially in the case of Mathematics Education, technologies provide a visual aspect of access to the content of this area of knowledge, where "… visual representations transform the understanding of mathematical concepts that require multiple representations" (our translation) [8].

The possibilities offered by technological tools are broad, encouraging deeper interaction among educational agents. Thus, it is fundamental to explore these resources strategically to enhance the learning experience and maximize the benefits of the technology-driven educational environment [9].

SOME SPECIAL EDUCATIONAL NEEDS AND THEIR IMPLICATIONS IN LEARNING

The term student with Special Educational Needs (SENs) comes from a construction and historical context of understanding education for students with some disability or specific learning difficulties [10]. It is important to reinforce that the care of students with SENs is the responsibility of all who work with education and not just specialized professionals [10]. In particular, this article aims to present and discuss aspects related to the learning of students with DD, CP, or VI.

DD is a learning disorder in Mathematics, defined by Kosc [11] as: "... a structural disorder of mathematical abilities which has its origin in a genetic or congenital disorder of those parts of the brain that are the direct anatomico-physiological substrate of the maturation of the mathematical abilities adequate to age, without a simultaneous disorder of general mental functions"[2].

To establish a standard in the definition of DD, manuals such as the International Classification of Diseases of the World Health Organization (ICD-11) [12] and the Diagnostic and Statistical Manual of Mental Disorders – DSM-5-TR [13] offer guidelines that assist in diagnosis. The ICD-11 [12] indicates that DD manifests mainly as a specific difficulty in mathematical abilities, not caused by inadequate teaching or intellectual disability.

In this same perspective, the DSM-5-TR [13] explains that dyscalculia is the term used to "... to refer to a pattern of difficulties characterized by problems in processing numerical information, learning facts arithmetic and in the execution of precise or fluent calculations"[3].

In his studies, Kosc [11] categorizes DD into six types: Verbal Dyscalculia, manifested by the deficient ability to verbally designate mathematical terms and relations, such as designating quantities and numbers of things, digits, numerals, operational symbols, and mathematical performances; Practognostic Dyscalculia, difficulty in the mathematical manipulation of real objects or figures, considering that mathematical manipulation includes enumeration and comparison of estimated quantities; Lexical Dyscalculia, impairment in reading mathematical symbols (digits, numbers, operation signs, and written mathematical operations); Graphic Dyscalculia, characterized by difficulty in manipulating mathematical symbols in writing, being analogous to Lexical Dyscalculia, often occurring in people with dysgraphia or dyslexia; Ideognostic Dyscalculia, impairment in understanding mathematical ideas and relations and performing mental calculations; Operational Dyscalculia, related to a deficiency in manipulating mathematical operations. It thus has a strong link with the use of fingers.

Complementing, Kosc [11] says that a student who presents this learning disorder has a development below what is expected for their age group, thus compromising their cognitive development. Furthermore, Lara [14] emphasizes "... that a difficulty is temporary, remedied with proper interventions. However, a disorder is perennial, it is alleviated with interventions, but it has no cure" (our translate).

Regarding CP, Rotta [15] states that the expression is considered as a sequel of an encephalic aggression characterized by a persistent disorder, it is not degenerative but mainly affects postural and movement development. According to Monteiro [16], the diagnosis of CP is neuroclinical, and neuroimaging exams are fundamental for identifying lesions and excluding diseases that may be associated, such as epilepsy. In addition, understanding motor impairment and the progression of clinical manifestations is necessary so that the most efficient therapies can be directed to the paralyzed individual.

Maranhão [17] presents a classification of CP types according to the type and location of neuromuscular impairment that affects the cerebral palsy patient, namely: Spastic; Dyskinetic; Ataxic; Hypotonic; and Mixed. As the author [17] reinforces, CP is not a transient pathology but definitive, although neural impairment may be altered over time. In this view, it becomes fundamental that adequate therapies and methodologies are directed to the individual, in an attempt to enhance their learning and constantly redesign their neuropsychomotor evolution.

Regarding students with VI, Demartini and Lara [18] state: "... this disability not only constitutes obstacles to learning, but can also make teaching work difficult due to the scarcity of resources that enable visual-auditory sensory substitution, for example" (our translation).

In this sense, according to the World Health Organization (WHO) [19]: "Eye conditions are remarkably common. Those who live long enough will experience at least one eye condition during their lifetime. [...] Young children with early onset severe vision impairment can experience lower levels of educational achievement, and in adults it often affects quality of life through lower productivity, decreased workforce participation and high rates of depression".

The use of assistive technologies that can contribute to the learning of students with VI plays a role as allies in the process of overcoming limitations. Each person with a disability has a unique condition, and from this particularity, can benefit from a method that best meets their needs [20]. With the development of the application and possible improvements through research, the blind audience can be reached, provided that the application already has sufficient audio description and narration elements to accommodate this audience.

METHODOLOGICAL PROCEDURES

This study adopts a qualitative approach of a theoretical bibliographic nature, which is considered an appropriate way to initiate research, as it allows identifying similarities and differences between articles consulted in reference sources [21].

Within the scope of the GEPEDPUCRS, systematic literature reviews have been conducted based on the steps established by Pickering and Byrne [22], aiming to identify theoretical foundations that serve as guidelines for the conception and development of the VR application. According to the authors, the SLR is considered systematic because the methods for selecting productions are clear and reproducible. Additionally, it is quantitative, as it quantifies the areas already researched, and comprehensive by evaluating different combinations of locations, themes, and variables for conducting the research [22].

The SLRs mainly analyze the objectives of each production, their contributions and implications for learning; the tools used; and, in particular, the accessibility resources utilized. The established descriptors vary among: applications; software; virtual reality; dyscalculia; cerebral palsy; and visual impairment.

Among the databases consulted for each of the reviews are: i) Brazilian Digital Library of Theses and Dissertations (BDTD); ii) Networked Digital Library of Theses and Dissertations (NDLTD); iii) Scientific Electronic Library Online (SciELO); iv) IEEE Xplore Digital Library; v) CAPES Portal of Journals; vi) Education Resources Information Center (ERIC); vii) Web of Science; viii) SciVerse SCOPUS; ix) EMBASE; x) Directory of Open Access Journals (DOAJ); xi) ACM Digital Library (ACM DL); xii) CAPES Theses and Dissertations Catalog; xiii) ScienceDirect.

The main inclusion criteria were: i) Being a scientific article, dissertation, or thesis; ii) Addressing the use of applications for students with DD, CP, or VI; iii) Presenting aspects of learning.

VIRTUAL REALITY APPLICATIONS AND ACCESSIBILITY – ANALYSIS OF RESULTS

Different resources can be implemented in an application with the aim of contributing to user accessibility. In these studies, those focused particularly on students diagnosed with DD, CP, or VI stand out.

Through SLR, scientific productions were selected that specifically address the use of resources that can contribute to the accessibility of students with the specified disabilities and SENs.

It is worth mentioning that an RSL was developed for each of the SENs addressed in the two major projects. However, for this article, those were selected that, when analyzed, created conditions for the emergence of the analysis category: *Resources that can facilitate accessibility*.

Table 1 presents the main selected productions, relating the addressed SEN, the type of production (article – An, dissertation – Dn, thesis – Tn), data about the production, and the search platform.

NEE	Tipo	Título/autores	Plataforma de busca
DD	A1	Evaluation Of Visual Based Augmented Reality (AR) Learning Application (V-ARA-Dculia) For Dyscalculia Learner/ Kohilah Miundy, Halimah Badioze Zaman, Aliimran Nosrdin, Kher Hui Ng	Periódicos CAPES
DD	D1	Recomendações para o design de jogos, enquanto intervenções motivadoras para crianças com discalculia do desenvolvimento Matheus Araujo Cezarotto[1]	BDTD
PC	T1	Ambientes de comunicação alternativos com base na realidade aumentada para crianças com paralisia cerebral: uma proposta de currículo em ação Tania Rossi Garbin (2008)[2]	BDTD
PC	D2	Realidade virtual na paralisia cerebral: o uso de tarefas por meio da realidade virtual na paralisia cerebral [3] Andrea Fernanda Leal (2018)	CAPES
DV	A2	Development of navigation skills through audio haptic videogaming in learners who are blind Jaime Sánchez (2012)	Science Direct
DV	D3	Audio games no processo de aprendizagem de deficientes visuais: análise sob o aspecto da mediação da informação Igor Peixoto Torres Girão (2018)[4]	BDTD
DV	D4	Tecnologia assistiva no ensino de Matemática para um aluno cego do Ensino Fundamental: Desafios e possibilidades Ligiane Gomes Marinho Salvino (2017)[5]	BDTD

Table 1. Main productions selected through the systematic literature reviews already conducted.

Regarding the resources used for students with DD, those presented by the authors of A1 stand out. They highlight that the application should avoid an overly decorated design to prevent confusing students with DD. However, the authors emphasize the importance of attractive visual resources in the learning modules, as these elements help students with DD to maintain attention and better understand mathematical concepts.

Regarding attention, Lima [23] states that attention can be defined as the individual's ability to concentrate predominantly on stimuli that are interesting to them, to the detriment of others. Based on this, it is essential that the application has attractive elements that keep students' attention, allowing them to carry out the proposed activities.

In D1, the author presents a series of recommendations for activities that can be incorporated into a game or application, aiming to motivate and contribute to the student's learning. To develop working memory, the author of D1 recommends that the activities used train the recall of mathematical facts and geometric shapes, for example, to develop fluency in accessing these facts. Regarding working memory, Swanson [24] refers to the preservation of information while simultaneously processing the same or other information, Thiele and Lara [25] emphasize that working memory is essential for the temporary retention of information and impacts complex processes such as reading, calculation, and mathematical comprehension. By developing this ability, the student will be able to perform activities that they previously could not.

Reinforcing this idea, the author of D1 highlights the need for repeated practice of activities, but in its application considering strategies not to harm the user's motivation due to excessive repetition. An alternative is to explore playful aspects to compose a fictional game context (with stages and levels), where repetition for learning will be inserted but not evident to the player. According to Costa et al. [26], learning is directly linked to the ability to memorize, as knowledge, learning, and lived experiences are stored in memory. For this reason, memorization plays a crucial role in the students' learning process.

However, Lara [14] emphasizes that depending on the type of DD the student has, the storage of numerical facts does not always occur, making it necessary to propose activities that provide opportunities to create other resolution strategies. In this sense, the author suggests "... shift the focus away from the abilities to perform precise calculations and memorize numerical facts, valuing the mathematical reasoning used in problem-solving" (our translation) [14]. Therefore, it becomes essential that in the conception of a VR application, the activities and challenges enable the student to learn Mathematics with meaning.

To develop number sense, the author of D1 recommends that the activities be focused on: "Comparison of numerosity; stimulate the relationship between numerical digits and quantity representations (scaffolding procedure); strengthen the relationship between the three mental models of numerical representation—analog magnitude, verbal, and Arabic (repeated association)" (our translation).

According to Corso and Dorneles [27], number sense refers to "... the ease and flexibility of children with numbers and their understanding of the meaning of numbers and related ideas" (our translation). When a student has developed number sense, they are able to estimate quantities, identify which number is greater than another, and understand the meaning of numbers. Therefore, the development of this ability is especially important for students with DD. Regarding the content of the activities, the author of D1 suggests that the activities developed should cover only one content and be segmented, avoiding multiple subjects in the same activity.

As for the game's instructions, they should be objective and inform the possible actions during the activity. The author of D1 recommends that: "For orientation, it is recommended to use a dual channel (auditory and visual) utilizing playful resources. An alternative is to use animated tutorials with explanatory examples at the beginning of each task, in addition to providing a help option during the game, aiming to address possible doubts, especially when starting new activities in the game" (our translation).

Corroborating this idea, Santos [28] mentions that feedback plays a fundamental role in pedagogical work with students, in different aspects, "... in the sense of guiding them in performing tasks, supporting the understanding of the behavior of the digital environment, and predicting the behavior of similar characteristics or elements." (our translation) [28].

Regarding the game's interface and visual resources, the author of D1 suggests that it should be simple and organized, with consistency in typography and colors, so as not to overload the player's cognitive processing. The graphic elements should allow intuitive navigation in the system, with basic menu controls such as start, pause, and adjust settings. The game's design should include controllable characters that can be customized as the player progresses. A similar idea was addressed in Menezes' research [29], which presented the need for representativeness and personalization of characters as a form of motivation in games and activities.

Regarding gameplay and game mechanics, the author of D1 highlights that it is essential to balance the player's skills with the presented challenges. The research recommends performing an initial leveling, adapting the difficulty level based on the player's skills. Additionally, it is essential that, if the game's objective is to improve a specific skill, the activities promote the automation of facts, allowing the player to solve more problems with greater accuracy and in less time, while the complexity increases as the player progresses. Furthermore, the author of D1 suggests that the setting is a crucial element in the game's playful context, varying according to the themes of the proposed activities, adapting to each situation.

When applications are aimed at students with CP, the accessed works argue that the use of such resources becomes favorable in the classroom to provide effective learning. In particular, when used by students with CP, it facilitates processes that paralysis often impedes, such as speech reading and writing, through virtual commands.

The author of T1 advocates possibilities of communication for children with CP, with interactive environments and using Augmented Reality (AR) systems and assisted communication software. Optical tracking of people's bodies or just their hands and different techniques can eliminate the use of technological equipment that is sometimes heavy or uncomfortable for the user. In addition, concerning users with CP, AR, because it does not keep them fully immersed in virtuality, does not require physical strength to be used, representing an important differential regarding its use directed at individuals with severe motor impairments.

In this sense, it is worth inferring that students with CP benefit from the use of virtual assistive technologies, as they receive greater autonomy to develop activities that, without such assistance, they would have difficulties of various kinds, which significantly influences the educational process of these people. When thinking about a VR application, it should be considered that it must provide adequate conditions for simulations and experiments by users, which in the case of students with CP, this adequacy involves very important considerations, such as controlling sensory disturbances stimulated by the individual's great visual and auditory exposure, motor facilitation through simplified commands that do not demand physical efforts exceeding the student's motor strength, in addition to virtual projections that are effectively conducive to improving the student's real conditions.

Another aspect highlighted by the author of T1 is that AR maintains the user's sense of belonging to the real environment, and that the sensation of complete immersion can cause vertigo in individuals with CP. Therefore, it is of utmost importance to evaluate this aspect when using virtual reality instruments, such as VR glasses with these students, so as not to generate these adverse effects and compromise the systematic use of the resource.

In the research presented in D2, the author shows that innovative tools for the treatment of CP, such as computational technologies, contribute significantly to the motor and functional rehabilitation of individuals with CP, facilitating their learning. However, it is important to emphasize that the use of virtual resources with students with CP must be done according to well-established criteria, the expertise of the applicator, and understanding of the implications of use to generate effective gains in the individual's learning. The author of D2 articulates that the physiotherapeutic intervention associated with VR differs from conventional physiotherapy because it enables faster acquisition of motor and multifunctional performance.

According to Bairral [30], applications promote new ways of teaching and learning by favoring changes in cognitive functions. From this understanding, applications appear as potential technological resources for the education of people with CP, as these students need resources that are not conditioned only to normal motor and speech capacity, since individuals with CP may not have this established domain.

In the case of the selected works focusing on students with VI, the studies pointed out that auditory stimuli help students with VI understand the functioning of applications and find information. These sounds can vary from distinct sound signals for each button or function to story narrations and sounds with 3D technology. Three-dimensional audio, applied in a virtual environment, uses the concept of biological interpretation of sound in the real physical world; for example, if the sound reaches the right ear first, this indicates that the sound source is positioned to the listener's right [31].

In any case, it is important that auditory stimuli are present in the resources to enable navigation and immersion in the proposal [32]. For Sánchez and Tadres [33], for the usability of an application for the visually impaired audience, the sound needs to provide indications about the position and location of objects, and it is important to use clearly identifiable sounds. Also, for Sánchez et al. [34]: “All of the actions in the virtual environment have a particular sound associated to them. In addition to this audio feedback, there are also spoken audio cues that provide information regarding the various objects and the user’s orientation in the environment. Orientation is provided by identifying the room in which the user is located and the direction in which he/she is facing, according to the cardinal compass points (east, west, north and south).”

In production A2, the author points to the importance of the presence of audio resources and haptic resources characterized as controls that emit vibration and can give sensations related to the weight of virtual objects. For the author of A2, the results of his studies indicate that the use of audio and tactile resources helps establish movement paths and navigation in the created virtual environment. Moreover, the use of 3D sound can create mental images and thus serve as a source of space representation for students with VI [35].

These auditory and tactile stimuli emerged in the analysis as important sources of immersion for students with visual impairment in digital stories and games. In addition, according to A2, they provide a realistic virtual experience, even for those with total blindness.

Regarding testing conducted with students and teachers, D4 showed that teachers highlighted the importance of their participation in validating resources, since they can offer a pedagogical perspective on the use of these materials and assess whether their inclusion in the classroom routine is feasible or not.

The author of D3 aimed to apply audio games, a type of game based on audio stimuli, to assist in the learning of students with VI. The advantages of this type of tool are accessibility and the playful way of providing student learning. Furthermore, he categorized sounds to help players better understand the environment, something essential for students with VI. This characterization was made based on the elements used by Crawford [36], in sounds of: scenario or setting; support to setting; interaction; characters; alerts or abstracts. For people with visual impairment, the sounds: "... must be sufficient for the player to be fully aware of everything involving aspects related to the game's environment, providing the ability to apprehend information, enjoyment, appropriation, and learning" (our translation) [36].

In this sense, for better understanding and to meet the special needs of students with VI, it is important to use sounds that provide all relevant information and promote motivation for them to perform activities in their entirety.

In the dissertation presented as D4, not all inclusive technologies highlighted by the author are digital, such as Braille tools, the abacus, screen readers, and audiobooks. She points out that these inclusive technologies play an important role in the effectiveness of the learning process in the case of students with VI.

In the SLR developed by Demartini and Lara [32], the authors highlight that the obtained analysis pointed out the need to create levels of challenges that generate attention and interest in students when creating an educational game or application. In addition, in the case of students with low vision, care with color contrast is essential, so that they can have a pleasant and accessible experience. For Kulpa, Teixeira, and Silva [37], this care with color contrast: "... are of great importance due to their ability to draw the user's attention, indicate interface aspects, facilitate memorization, create backgrounds, direct reading, and allow the user to assign meaning and value to these interfaces according to their interpretation. The contrast between colors allows locating and facilitating the reading of texts, even for colorblind individuals who do not perceive certain colors" (our translation).

Among the different inclusive technologies presented in the research, the author of D4 mentioned DOSVOX as one of the resources that assist students with visual impairment because they process the reading of texts that are on the screen, as well as the buttons that are typed. The use of this application is also addressed in Malaquias [38] for students with VI.

The analyzed articles and dissertations point to several technological approaches that can be implemented in the application to improve accessibility and motivation of students with different SENs. These findings can be fundamental to further qualify the environment being developed.

Among the productions, the resources used for students with DD and VI suggest that the design of the application being developed by the GEPEDPUCRS should be simple and avoid decorative excesses that may distract users. However, it is important that there is customization of the environment, as well as activities that make use of repetition to train skills progressively, increasing difficulty according to the user. Text reading software and button activation can be essential for a good adaptation of students with VI to the environment being developed, because depending on the degree of VI, sound can be the main aid factor for these students. Regarding the application's interface and virtual environments, it is recommended that it be simple and organized. Navigation through the environment should be intuitive, with basic menu controls and adaptation tutorials. A strong contrast between colors is suggested, as well as customizable characters that make sense with the application's target audience, so that they feel a sense of belonging and familiarity. According to Araújo et al. [39]: "High contrast and colorblind design options are important for players with low vision or color blindness so that it is possible to distinguish important areas related to game menus and navigation" (our translation).

Among the resources found, currently the application that is under development will include auditory assistance and strong color contrast between objects. In some of the activities, there is already repetition and gradual increase of difficulty level according to the number of correct answers made. Navigation, as well as the environment's tutorial, has not yet been developed, so the analysis of the productions will be useful to enhance the environment. It has not yet been tested whether it is possible to integrate applications like DOSVOX with the application environment being developed within Unity. However, the project includes the insertion of auditory feedback for actions within the environment, although it has not yet been implemented. Customization of the environment will be done after the completion of activities, as it is a simpler process within environment programming.

The schooling of students with SENs in regular schools requires discussions and the adoption of new practices that enable these individuals' learning. In this view, assistive technology resources are enhancers and learning aids and can contribute significantly to achieving increasingly inclusive education focused on the students' potential development, overcoming barriers that traditional schools still present.

Although the selected productions did not emphasize the teacher's role, through studies developed by researchers who are part of the research group led by Lara [40], she states that it is essential to recognize the student's diagnosis, understanding the different learning disorders, particularly in Mathematics, and their characteristics, so that they can value the different ways of mathematizing presented by students. In the case of students with CP and VI, this understanding by the teacher is equally relevant, as well as by people involved in the development of any type of technological resource, so that it is possible to provide an experience concerned with developing impaired skills and enhancing the existing ones.

CONCLUSION

After analyzing the selected productions, it became evident that when developing the application, it is crucial to adopt certain precautions to ensure that it truly assists the students involved in the study. The authors of the productions related to DD and VI highlight the importance of paying attention to the colors used in the activities, avoiding excesses that may distract students. To encompass those with DD, the application should present activities that motivate students so they do not lose interest. Moreover, it is important that the activities focus on a single specific content so that students can better develop what is requested. Additionally, the colors should not be so flashy as to confuse the students.

Considering students with CP, due to the limitations imposed by paralysis, which may compromise speech and handwriting, it becomes necessary to create virtual environments with simple interfaces to facilitate and promote communication, favoring the autonomy of these individuals.

The connections among all the cited works that discuss the use of technological resources, especially VR applications, to promote the learning of students with SENs, indicate the efficiency of such resources in this endeavor. It is feasible to apply them in the classroom to sensorially stimulate individuals exposed to technologies and, from that, develop motor and cognitive potentialities necessary for their overall learning.

It is necessary to envision an education that effectively addresses diversity, that can consider inclusion from the paradigms to which it is linked to the pedagogical practices that subjectify the individual in a range of techniques they need to master to be a good student, without valuing the development process itself, but purely the result. The individual with CP in school finds themselves stigmatized within this model that contemplates the so-called normal and ignores the need to adapt traditional resources used in the classroom. Using technology is not sufficient to recover students' learning; it is necessary to have objectivity, expertise, and analytical capacity to evaluate its use from the beginning and throughout the entire utilization process.

Although training is a very present objective in some analyzed productions, it is emphasized that not always does the student have this capacity, particularly students with DD. In this sense, it is suggested that in the conception of the VR application, activities and challenges be inserted that provide opportunities for students to create other resolution strategies. It is necessary to value the student's protagonism, highlighting the action plans they can devise and their mathematical reasoning.

Another finding worth mentioning is the fact that such accessibility resources do not limit their effectiveness to Mathematics teaching alone but can also be considered for learning in other areas of knowledge.

Up to this point, four activities have been finalized involving different mathematical concepts, namely: number construction; solving first-degree equations; fractional rational numbers; and solving right triangles. The environment is integrating various accessibility features, such as contrast adjustments, audio guides, options to zoom in and out of objects, and adapted control settings. These functionalities ensure that all students, regardless of their specific needs, can participate inclusively.

Thus, the application can be used individually or with more students from the teacher's class, creating conditions that foster social interaction. It is again emphasized that, although this application is being designed based on the profiles of students with DD, CP, or VI, it can also be used by students without Special Educational Needs (SEN), with the purpose of creating an inclusive and interactive classroom environment.

Once the four activities are completed, pilot interventions will be conducted with students and their respective teachers to assess the application in terms of the features used, its layout, and accessibility. This feedback will enable the application to be refined with the aim of optimizing its effectiveness.

Finally, it is worth mentioning that there is no intention to generalize the results to the three SENs addressed in this review. However, each of the resources can contribute in some way to each of them, not becoming an obstacle, but rather seen as an additional alternative to explain or understand the proposed activities.

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