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Inclusive Digital Technologies in the Classroom: A case study focused on students with Autism Spectrum Disorder (ASD) in the final years of elementary school

Tecnologias Digitais Inclusivas em Sala de Aula: Um estudo de caso com foco em alunos com Transtorno do Espectro Autista (TEA) nos anos finais do Ensino Fundamental

Tecnologías digitales inclusivas en el aula: un estudio de caso centrado en estudiantes con Trastorno del Espectro Autista (TEA) en los últimos años de la escuela primaria

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Abstract
Inclusive education in Brazil is part of an educational policy from the Law of Directives and Bases of National Education (LDBN 9394/96), which determines that people with special needs must be included in regular education classrooms. Overall, educational institutions lack professionals and content that favours inclusive education. The current work focused on students with Autism Spectrum Disorder (ASD), aiming to create and validate didactic sequences with the use of augmented reality (AR) to increase class engagement whilst providing to teachers and their assistants tools for the creation of other didactic sequences regardless of the curricular component. The research was exploratory, using the procedures applied in case studies. Once the bibliographic study was carried out and the AR tools pre-selected, the authors collected data with teachers and later suggested and validated the didactic sequences carried out by the students. The research showed the potential of AR as a tool to engage and make it possible to incorporate adapted school activities in order to have a greater participation of students with ASD. It was observed that training teachers and assistants to use other digital technological resources is essential for other practices to be developed and for the inclusion process to become increasingly natural.
Keywords: Autism spectrum disorder; Augmented reality; Didactic sequence; Assistive technology.

Resumo

A educação inclusiva no Brasil faz parte de uma política educacional da Lei de Diretrizes e Bases da Educação Nacional (LDBN 9394/96), que determina que pessoas com necessidades especiais devem ser incluídas nas salas de aula do ensino regular. De modo geral, as instituições de ensino carecem de profissionais e conteúdos que favoreçam a educação inclusiva. O presente trabalho teve como foco alunos com Transtorno do Espectro Autista (TEA), com o objetivo de criar e validar sequências didáticas com o uso de realidade aumentada (RA) para aumentar o engajamento da turma e fornecer aos professores e seus assistentes ferramentas para a criação de outras sequências didáticas independentemente do componente curricular. A pesquisa foi exploratória, utilizando os procedimentos aplicados em estudos de caso. Realizado o estudo bibliográfico e pré-selecionadas as ferramentas de RA, os autores coletaram dados com os professores e posteriormente sugeriram e validaram as sequências didáticas realizadas pelos alunos. A pesquisa mostrou o potencial da RA como ferramenta para engajar e possibilitar a incorporação de atividades escolares adaptadas para uma maior participação dos alunos com TEA. Observou-se que a capacitação de professores e auxiliares para o uso de outros recursos tecnológicos digitais é essencial para que outras práticas sejam desenvolvidas e para que o processo de inclusão se torne cada vez mais natural.
Palavras-chave: Transtorno do espectro autista; Realidade aumentada; Sequência didática; Tecnologia assistiva.

Resumen

La educación inclusiva en Brasil es parte de una política educativa de la Ley de Directrices y Bases de la Educación Nacional (LDBN 9394/96), que determina que las personas con necesidades especiales deben ser incluidas en las aulas de educación regular. En general, las instituciones educativas carecen de profesionales y contenidos que favorezcan la educación inclusiva. El presente trabajo se enfocó en estudiantes con Trastorno del Espectro Autista (TEA), con el objetivo de crear y validar secuencias didácticas con el uso de realidad aumentada (AR) para aumentar la participación en clase y brindar a los docentes y sus ayudantes herramientas para la creación de otras didácticas. secuencias independientemente del componente curricular. La investigación fue exploratoria, utilizando los procedimientos aplicados en estudios de casos. Luego de realizar el estudio bibliográfico y preseleccionar las herramientas de RA, los autores recolectaron datos de los docentes y posteriormente sugirieron y validaron las secuencias didácticas realizadas por los estudiantes. La investigación mostró el potencial de la RA como herramienta para involucrar y posibilitar la incorporación de actividades escolares adaptadas para una mayor participación de los alumnos con TEA. Se observó que la formación de docentes y auxiliares para el uso de otros recursos tecnológicos digitales es fundamental para que se desarrollen otras prácticas y que el proceso de inclusión sea cada vez más natural.
Palabras clave: Desorden del espectro autista; Realidad aumentada; Secuencia didáctica; Tecnología de asistencia.

1. Introduction

The first epidemiological studies on Autism Spectrum Disorder (ASD) were documented in the 60s and 70s in England, by Lotter (1966) and Wing (1979), and in the United States by Treffert (1970). Elsabbagh et al. (2012) in their study entitled Global Prevalence of Autism and Other Pervasive Developmental Disorders, work commissioned by the WHO, estimates that 1 in 160 children presents autism spectrum disorder. In the Americas, the United States and Canada are the countries that stand out in the exposition of case reports on the subject. In South America, Argentine and Venezuelan researchers have published academic works (2 studies) on the subject, whilst in Brazil the discussion seems to be still incipient.

Isolated efforts seeking more precise data are present in the Brazilian literature, as it was observed in the city of Atibaia. In a pilot study carried out by Ribeiro (2007) it was found that the proportion of ASD cases was 1 to 3, considering girls and boys, respectively. The research focused in a district of the city, totalling 470 children, aged between 7 and 12 years. It was noticed that 76 of them, that is 5.1% of the total, were diagnosed with some pervasive developmental disorder (PDD).

The research faces several obstacles regarding its scalability. As mentioned by Ribeiro (2007) the participants' difficulties in understanding the questionnaire, lack of staff to assist in the application of questionnaires and practical questionnaires usually affects the complete application of the screening protocol in all individuals. As of 2022, with Law 13.861/19, more information about autism will be obtained in the national territory.

In Brazil, there is no detailed study on the number of autistic people in the country, although it is estimated that there are 2 million people in this condition. With Law No. 12,764 (Berenice Piana Law), of December 2012, Brazil instituted the National Policy for the Protection of the Rights of Persons with Autism Spectrum Disorder.

Guideline VII of article 2 of law 12,764/12 emphasizes the encouragement of training and qualification of

professionals specialized in caring for people with autistic spectrum disorder, as well as parents and guardians. The objective with training and qualification is to favour the integration and real inclusion of those belonging to the ASD in regular schools, communities and families.

The implementation of an inclusive practice as well as the guarantee of teaching quality, providing the necessary conditions for students, is continuous and dynamic process, especially because the school is in constant transformation, built on people and different realities. (Bersch, 2009). Inserted in the debate of inclusion of students of various types of disabilities in the cognitive field, this article will focus on discussing the autism spectrum disorder as a reality in Brazilian schools.

At the educational level, Manzini et al. (2005) affirms that the adaptation of pedagogical resources would be possible for issues such as learning and development to improve simultaneously. The adaptations endeavour to make possible for the student with some type of disability to be able to have their learning enhanced, a situation that would not occur without the help of such assistive technology.

According to Bersch (2006) assistive technology is the set of resources and services that contribute to providing or expanding functional skills for people with disabilities, and consequently promoting independent living and inclusion. For assistive technology to be successful, making the appropriate resource selection is essential, thus the importance of student participation. The interaction between the team that will make the assistive technology available and the student may lead to greater autonomy for the student and further usability for the solutions.

The motivation for the current research arose from the authors' perception of the learning routine of children with ASD, sometimes characterized by significant idleness, since conventional activities are not suited to their cognitive variability. Through observation, the authors also realized that classroom assistants (generally psychologists, pedagogues, psychopedagogues and speech therapists) with exclusive responsibility for these students failed to contribute to mitigate this scenario. Thus, the current study proposes an investigation into how to improve the learning experience in the classroom by children with ASD through the application of assistive technologies, especially those considered low cost.

2. Methodology

Kirner et. al. (p. 290, 2006) suggest that augmented reality environments allow the users to experience sensations. The interface allows the child with special needs to establish new connections and, through their actions (natural behaviour), interaction occurs more naturally.

Augmented reality allows the superposition of objects and virtual environments with the physical environment, through technological devices (Kirner & Siscoutto, 2007). With the popularization of smartphones and mobile networks, this technology has attracted the attention of several market segments such as gaming.

There are already several tools available to work with augmented reality. Both free and paid as well as tools that mix free and paid features. In the current article it was utilized applications/platforms that were either free or had free features. Thus, one of the intimal steps of the work was searching for applications that could favour the autonomy of the teacher or help to create didactic sequences for students with ASD. Within that criteria, the following applications were identified:

Table 1 - Platforms and apps with AR to create didactic sequences with AR

Name	URL	Features
Metaverse	https://studio.gometa.io/landing	Story creation, tours, quizzes, online editing.
Eon-XR	https://eonreality.com/platform/	Free version limited to creating 5 lessons. Variety of free and paid 3D elements for creating classes.
Assemblr	https://www.assemblrworld.com/	Robust platform for the creation of lessons; Software download required to create lessons; Application with educational emphasis to use the created sequences; Possibility of interaction with virtual objects.
QuiverVision	https://quivervision.com/	Platform with paid and free options; Some AR experiences have lessons to complement the experience; The drawing feature can be a differential to create interrelations with students between real and virtual.

Source: Authors.

The next stage was starting the process of creating the didactic sequences, that is, the set of ordered, structured and articulated activities to accomplish specific educational goals, which have a beginning and an end known by teachers and students alike. Such definition is utilized in the current article as to contribute in a clear and objective way to the teaching of children with ASD, also giving the educators autonomy for the development of new didactic sequences with the use of the three phases: planning, application and evaluation (Zabala, 1998).

According to Zabala (1998), learning depends on the unique characteristics of each one of the learners; largely corresponding to the experiences that each one has had since birth; the way one learns and the pace of learning varies according to abilities, motivations and interests. For Libâneo (2006), the teaching process is driven by factors or specific conditions that already exist or that it is up to the teacher to create, in order to achieve school goals. Therefore, it is necessary to pay attention to the diversity of students when creating didactic sequences, including student with ASD or another disability or even the neurotypical ones; they should have didactic sequences closer to their realities. However, the non-occurrence of this personalization of teaching is more visible when students with special educational needs are left idle state, even with assistants' involvement, and content is not adapted to their reality.

Libâneo (2006) states that the teacher plans, directs, organizes, controls and evaluates teaching with specific goals: the active learning of the student as well as the cognitive relationship between the student and the subject of study.Once the answers to the questionnaire were analysed and the objects of knowledge that would be worked with that student were evaluated by the participant teacher, the creation of the didactic sequence was initiated. For this purpose, data was collected through survey (Gil, 2002), so that the researchers could analyse the teachers' profile (training to work with ASD, interest in increasing student engagement) as well as understand the characteristics and abilities of students with ASD from the teacher's point of view.

According to Gil (2002), data collection in case studies is complex and the data collection must be carried out through different procedures in order to validate the study, preventing it from being subordinated to the subjectivity of the researcher. According to Yin (2001), the case study is seen as the most adequate design for the investigation of a contemporary phenomenon within its real context, where the limits between the phenomenon and the context are not clearly perceived. Furthermore, Gil (2002) emphasizes that, when using the case study, it is necessary to take due care in planning the research so

that its results do not become just a pile of data. For Severino (2010) the chosen case must be significant and well representative, in order to be able to support a generalization to similar situations.

The research was developed in a private school in Natal, the capital city of the state of Rio Grande do Norte, in Brazil, with 2 students from the 6th year of the Final Years of Elementary School. The students who participated in the survey are within the mild degree of the autistic spectrum. The first one here called student01 is 12 years old, uses tablets and notebooks to watch videos, is literate and usually walks a lot in class whether something has caught his attention or not. Student02 is 12 years old, he also finds it easy to use digital resources. However, Student02 finds it easier to maintain the routine, remains seated during classes, answers when asked, and has considerable autonomy to perform the assigned tasks.

The 6th year of teaching was chosen as it brings significant change in the routine of the student with ASD. Instead of only one teacher, they will experience about 10 different teachers when reaching the final years of elementary school. In the following stage, the AR tool to contribute with the proposed activity was selected (the tools proposed on Table 1 were utilised).

Science teachers suggested the Syllabus on Cells, as it would be the first contact of these students with AR. Hence a didactic sequence was created the by the researchers that started with paintings in the animal and plant cells and then with the help of the QuiverVision application, the students pointed to the screen to visualize the cell. An analysis of the application of didactic sequences will be posteriorly presented in the results.

Figure 1 - Cell painting.

Source: Authors.

Figure 2 - Visualization with AR.

Source: Authors.

After the first experience, Metaverse software started to be utilised. With an application available on the Apple Store and Play Store, in addition to an online platform for creating experiences with augmented reality, we used the knowledge object: Verbs. This didactic sequence was created so that students could perform actions of their daily lives such as running, sitting, jumping. The sequence triggering was rather straight forward, the students pointed only once to the QR Code and then they were able to live the experience with more freedom. It is worth noting that in the application of this sequence all students participated, not only those with the diagnosis of ASD, which allowed the researchers to have an inclusion process as proposed in guideline VII of article 2 of law 12.764/12 (Berenice Piana Law).

Figure 3 - Activity Explanation.

Source: Authors.

Figure 4 - Application with AR.

Source: Authors.

3. Results and Discussion

The purpose of this article was to carry out a study on how a didactic sequence with augmented reality could be created in a way that would serve as a support for the assistants of students with Autism Spectrum Disorder (ASD) so that when applying the content in an adapted way to autistic children they could be more integrated and less idle in the classroom.

The choice for augmented reality comes from the statement by Soares (2017) that children with ASD show considerable interest in electronic devices, such as computers, smartphones, tablets and video games, and by Rosa (2018) that AR offers the user greater interactivity and increases the chances of using the application; furthermore, teaching pedagogical content with the help of AR presents a certain didactic differentiation, making this task more dynamic and enjoyable for both the student and the teacher.

With the didactic sequences created the assistant and/or teacher and the student only needed a device (smartphone or tablet) compatible with the application so that the interaction with the augmented reality resources took place in the classroom itself.

3.1 Survey – Teachers

A survey in which the participating teachers answered questions related to their experience with children diagnosed with ASD and their observations about the child was applied. 10 teachers responded to the survey, from the following curricular components: 4 of Science, 2 of Geography, 1 of Arts, 1 of Mathematics, 1 of English and 1 of Portuguese.

Amongst the participants, all reported having students diagnosed with ASD, but only 1 teacher (10%) claimed to have proper training to work with this type of student. The lack of training (40%) and time for planning (40%) were the points considered by teachers as the most difficult to include these students in their classes.

30% of the teachers who answered the questionnaire did not have their didactic sequence adapted for students with ASD, whilst (20%) were not aware if it was adapted, but when asked if they would be interested in applying didactic sequences with augmented reality as a way to increase their student's engagement in classes all answered yes.

3.2 Survey – Teachers' perception on the students

Once information about the teacher's experiences with children with ASD was collected, they were requested to inform how they perceived such students in the classroom. The authors aimed to understand how the participation of students in the classroom was and 70% reported that students only interacted sometimes.

When the authors asked about the type of class in which the student participates the most, the answers were quite varied and inconclusive. Which leads to the reflection that it is dependent on several factors within the context and the subject that will be addressed, and each student has different characteristics and interests.

Regarding the use of digital technologies by students with ASD, none of the research participants stated that students would have little or no interest in technological resources. As the digital technological resource in which the students would be most interested, the tablet is predominant over smartphones and notebooks. Regarding classroom support, 70% said that the greatest need is for verbal support.

The last question concerns the skills and/or behaviours that already exist in students with ASD. This question was adapted from the Assessment of Basic Language and Learning Skills (ABLLS-R) assessment protocol, which assesses basic language and learning skills in various contexts of the routine of a child with ASD. In this article it is used the topic: following classroom routines. The highlights are: Does the student follow guidelines upon request? (Example: queuing up) (50%) and He is literate (70%).

The teachers who answered the survey teach in the 6th grade of the Final Years of Elementary School, which represents students aged 11 years. Results so far make clear the contact of teachers with children with ASD is existent, as it is the interest in having proper training to work with them, but the lack of time and suitable training are factors that can directly impact the creation of didactic sequences that favour the teaching-learning process for students with ASD. The teachers' view of their students also shows that students have considerable contact with digital technological resources and that the tablet is the most utilised one.

3.3 Didactic sequences

It was observed that the use of augmented reality in didactic sequences is an interesting way for practices to be developed with students. During the application of the didactic sequences, a greater engagement of students with ASD was evidenced; however, it does not mean that only activities with AR should be applied to students, they are strictly auxiliary tools. What the research has shown is the increasing importance of training so that teachers and assistants can adapt activities for students in a continuous and systematic search for inclusion. After the application of the didactic sequences, a new survey was applied to the teachers and assistants involved to verify their perception of what was accomplished. The survey was developed based on the ABLLS assessment protocol and was answered by 1 teacher and 1 assistant.

Initially, it was asked if the student was able to follow the instructions to move between one area of the room and another when requested. In 50% of the applications the student did this independently whilst the other 50% needed a warning.

When asked if the students waited their turn to perform the commands and if they performed the activity independently of other situations that occurred in the classroom, 50% of the answers were independently and 50%, after a warning. The fact that in all questions the students performed the requested didactic sequence can be considered a satisfactory accomplishment.

When asked if any of the students had difficulty using the tablet or smartphone, 100% said no. And only one student needed motor help to perform the activity. When we asked if they would carry out other activities with AR and if this type of activity could increase the engagement of students with ASD in the classroom in order to favour learning, both teacher and assistant said yes.

3.4 Application analysis - Didactic sequence 01

Along with the teacher's assistant, student01 was presented with the class proposal and showed interest. As he likes to stand, he was left free to choose where he would do the activity. The engagement started very well with the painting of the

parts of the animal cell. It was observed at this point that the student identified the patterns of part of the cell by filling in a colour for each part.

Figure 5 - Application with student01.

Source: Authors.

At the end of the painting, the student started the process of seeing the cell with the resource of augmented reality. At first, engagement remained high with the student using their finger to rotate the image, see the name of the cell parts, rotating and zooming the smartphone to see the cell more closely. However, upon discovering that he could move the mobile phone, the student could no longer see the images, since the camera had to be pointed at the drawing. After 3 more attempts the student lost interest.

Student02, who was from another class, performed the activity at another time. His development was much more fluid than that of student01, even though they both had the same degree of autism, the mild one. He demonstrated a high engagement throughout the course of the didactic sequence, even in the activity to identify the parts of the cells after the moment of exploration with the resource of augmented reality. By leaving student 02 free, he maintained his interest in observing the cell with the augmented reality feature. He had no difficulty observing the cell even as he moved the smartphone to see the cell more closely or at different angles.

The didactic sequence 01 demonstrated that the QR Code may not favour students who like to move around the room more often, the smartphone utilised needs to have good processing power and the internet connection also needs to be stable. In this sequence it was utilised an iPhone 7 with 4g connection which caused a certain slowness. When migrating to a WIFI connection, the performance of the application, which at first needs to download the content to be viewed in AR, has significantly improved. Another factor observed is that the didactic sequence was applied only to the same ones, that is, students with ASD had an adapted sequence applied differently from neurotypical students. After the application and in conversations with the assistants and teachers, it was observed that it would be possible for the lesson to be applied to the whole class.

Figure 6 - Application utilization indication.

Source: Authors.

Figure 7 - Visualization with AR.

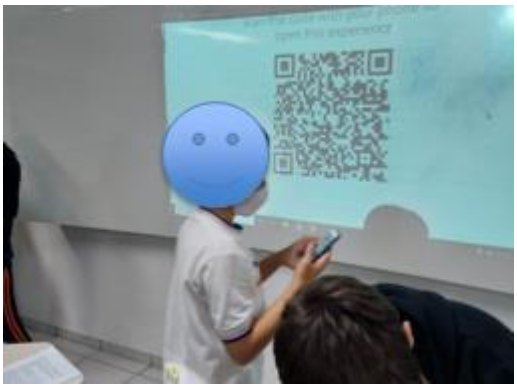
Source: Authors.

3.5 Application Analysis - Didactic Sequence 02

After the first experience, it was created a didactic sequence for the Portuguese Language subject, which at first seemed quite challenging when observing the proposed object of knowledge: Verbs. However, after some conversations and research, it was noticed how important the learning of such an object of knowledge is for the development of the autonomy of children with ASD. Another concern experienced in the second didactic sequence was that all students in the class used the same didactic sequence, which provided an opportunity for proper inclusion.

It was utilised the Metaverse app available for Android and iOS, which allowed all students to use it in the classroom. The first point to observe in this sequence was the dynamics of the school's internet network, since its firewall blocks certain applications. The application worked with students in various contexts in addition to Augmented Reality, such as text and audio explanations in the application itself, which allowed greater autonomy for children.

Figure 8 - Using the QR Code.



Source: Authors.

The first moment of the class was developed by the Portuguese language teacher on the object of knowledge Verbs. After the initial speech, the students were instructed to open the application and point to the QR Code available on the classroom board. After starting the experience, the students no longer needed the QR Code, which favoured the dynamics of the activity. The students were able to perform the requested actions during the course of the activity. The development of student01 and student02 was rather satisfactory. As student01 usually moves a lot, situations in which he could run, walk and also sit were introduced so that this skill could be developed. Student02 was very attentive and autonomous to carry out the actions proposed in the didactic sequence.

Figure 9 - Action of sitting with AR performed by the student.

Source: Authors.

The didactic sequence 02 brings the reflection that with training and interest from all parties it is possible to have adapted and really inclusive activities. The use of digital technology by students with ASD also favoured the application of this activity, since they had the autonomy to advance between the actions that were proposed in the activity.

4. Conclusions

Throughout the research it possible to visualize the many possibilities of activities to carry out with the students, that the fear of failing to apply the didactic sequences with students with ASD was decreasing as the contact with them increased, that listening or reading the demands of teachers give space to engagement to further develop students with ASD. It is known that the process of inclusion in regular schools is already taking place and tends to increase with each passing year, but for

inclusion to happen in all its aspects it is still necessary continuous and systematic training, individualized monitoring, and increasingly clear processes.

This article presented an approach with the use of a technology that is not yet common in schools, but that can have a significant impact on both students and teachers. The questionnaires applied made clear the teachers' interest in engaging these students, in getting to know new digital technologies, in participating in the processes of creating adapted didactic sequences and that training to work with such an audience is very important. In view of what was seen in the surveys and the didactic sequences developed and applied, it was found that the participation of students with ASD was more active and that they were able to further interact during the learning process, this analysis considers the curricular units involved in the research.

A point to highlight was the non-participation of the assistants during the production of the didactic sequences due to existing schedule demands. On the other hand, their participation during the application was noted as very important, since there is a contact and trust of students with ASD with them. Their greater participation in these productions can be favourable to enable the production of didactic sequences that are increasingly personalized for students.

Regarding the use of augmented reality platforms and applications analysed during the research, it is evident that there is already free material to be explored by teachers in order to create didactic sequences with relevant experiences with AR for students. It is also a fact that the help manuals available are not always didactic and do not facilitate learning, which will require time to study and analyse the tools available. In the current article, free tools were analysed, focusing on the educational demands that can be met with the use of augmented reality technology.

When returning to the initial question of this research "How to improve the use of learning in the classroom of children with ASD?" it was observed that the use of augmented reality can actually favour such engagement, in addition to the didactic sequence itself having already been adapted for them, we still have the visual aspects and digital resources that collaborate for this. Therefore, the authors sustain that it is possible that this research can be continued for a larger audience of children with ASD at different levels of education, so that by generating visual exhibitions with AR and different objects of knowledge, they can generate not only technical knowledge in the students, but also knowledge that can provide autonomy for everyday tasks.

Finally, it is expected that the current research can contribute to encouraging teachers from the most diverse areas of knowledge to apply adapted didactic sequences, either with augmented reality or other digital technology for students with autism spectrum disorder.

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