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Universal Design for Learning in teaching of Mathematics: theoretical and practical aspects in the education of students with visual impairments

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Abstract: This work has as objective to discuss and reflect on the principles of Universal Design for Learning and the development of inclusive practices, considering the presence of students with visual impairments in Mathematics classes. It is a qualitative research, inspired by the principles of action research, in which activities, strategies, and pedagogical resources that enable engagement, different means of representation and expression will be presented and discussed, aiming to provide accessibility to students. As results, the replacement of the verb "to adapt" by the expression "to make accessible" is proposed, highlighting the importance of offering students varied means of access to content and the need to conduct collective discussions on global themes, so that everyone can participate in the proposed activities. Thus, it is expected to advance towards more inclusive teaching practices, which enable the right to learning, emphasizing the need to (re)think and encourage students' protagonism in mathematics classes.

Keywords: Inclusive Practices. Engagement. Multiple Representations. Action and Expression.

El Diseño Universal para el Aprendizaje en la Enseñanza de las Matemáticas: aspectos teóricos y prácticos en la educación de estudiantes con discapacidad visual

Resumen: El objetivo del trabajo es discutir y reflexionar sobre los principios del Diseño Universal para el Aprendizaje y el desarrollo de prácticas inclusivas, especialmente teniendo en cuenta la presencia de estudiantes con discapacidad visual en las clases de Matemáticas. Esta investigación cualitativa se inspira en los principios de la investigación acción, con el fin de presentar y discutir actividades, estrategias y recursos pedagógicos que promuevan el compromiso, diferentes medios de representación y expresión, con el objetivo de proporcionar accesibilidad a los estudiantes. Como resultados, se propone reemplazar el término "adaptar" por "accesibilizar", enfatizando la importancia de ofrecer a los estudiantes diversos medios para acceder al contenido y la necesidad de realizar discusiones colectivas sobre temas globales para que todos los estudiantes puedan participar en las actividades propuestas. Así, el objetivo es avanzar hacia prácticas de enseñanza más inclusivas que garanticen el derecho a aprender, destacando la necesidad de (re)pensar y fomentar el protagonismo de los estudiantes en las clases de Matemáticas.

Palabras clave: Prácticas Inclusivas. Compromiso. Múltiples Representaciones. Acción y Expresión.

O Desenho Universal na Aprendizagem no ensino de Matemática: aspectos teóricos e práticos na educação de estudantes com deficiência visual

Resumo: O trabalho tem por objetivo discutir e refletir sobre os princípios do Desenho Universal na Aprendizagem e o desenvolvimento de práticas inclusivas, quando se considera a presença de estudantes com Deficiência Visual nas aulas de Matemática. Trata-se de uma

pesquisa qualitativa, inspirada nos princípios da pesquisa ação, de modo que serão apresentadas e discutidas atividades, estratégias e recursos pedagógicos, que possibilitam engajamento, diferentes meios de representação e expressão, objetivando proporcionar acessibilidade aos estudantes. Enquanto resultados, propõe-se a substituição do termo "adaptar" por "acessibilizar", destaca-se a importância de se oferecer aos estudantes variados meios de acesso aos conteúdos e a necessidade de se conduzir discussões coletivas, com temas globais, de sorte que todos possam participar das atividades propostas. Assim, espera-se avançar em direção a práticas de ensino mais inclusivas, que possibilitem o direito ao aprendizado, destacando a necessidade de se (re)pensar e incentivar o protagonismo dos estudantes nas aulas de matemática.

Palavras-chave: Práticas Inclusivas. Engajamento. Múltiplas Representações. Ação e Expressão.

1 Introduction

In the past three decades, Brazil has experienced importat advances in educational policy guidelines regarding inclusive education, which have strongly impacted educational spaces, professionals and other students, who now coexist with diversity in the classroom. Data from recent school censuses indicate a substantial increase in the number of students with disabilities enrolled in regular mainstream schools, signaling an achievement for society as a whole. Despite that, inclusion policies implemented since the 1990s have been characterized by an initial focus on ensuring access to schools, yet they have failed to adequately address the critical questions of who is responsible for creating the conditions that allow students with disabilities to thrive in these environments, who should implement accessibility measures in their various forms, and how to transform the initial and ongoing training of teachers and education professionals to effectively support these students across diverse educational settings. Another challenge posed to schools and teachers relates to the learning of these students, as phrases like "I was not prepared for this" and "he is a student of AEE (Specialized Educational Assistance)" are common. In this way, the idea that the responsibility for ensuring the successful participation and learning of students with disabilities falls solely on the students themselves and their families persists, with the failure of these students often attributed to their disabilities.

It is pertinent to mention that over recent years, the history of inclusive education follows a timeline that begins with the exclusion of students with disabilities from schools, passes through the period of segregation within the school space, advances towards integration, culminating in the current moment, where the importance and necessity of inclusion are understood, especially considering education as a matter of Human Rights. In this historical trajectory of struggles and achievements, Pletsch (2020) highlights that there have also been epistemological advances and conceptual changes to explain the phenomenon of disability and school inclusion, progressing from understanding disability as a problem of the individual, linked to their limitations, to analyses based on the support offered to these individuals, until the moment when it is understood that disability should be analyzed based on the social and rights model.

The central thesis of this perspective, according to Diniz, Barboza & Santos (2009), "allowed for the shift of the issue of disability from domestic spaces to public life. Disability is no longer a matter of private life or family care, but rather a question of justice" (p. 69, our translation). The advancement of this understanding of disability as a public (and no longer private) issue has expanded the debate on the possibilities and potentialities of these individuals, based on the accessibility conditions provided by society and the school, which does not deny

disability, but human existence and the rights of individuals that cannot be defined by it, as pointed out by Pletsch (2020).

Motivated by the challenge of advancing the right to remain in school and learn for students with disabilities, it was during the years 2000, 2002, and 2011 that the English Tony Booth and Mel Ainscow developed studies and research that culminated in the publication of the text "Index for Inclusion: developing learning and participation in schools" (Booth & Ainscow, 2011). After its translation in 2012 by Professor Mônica Pereira dos Santos (Faculdade de Educação – Universidade Federal do Rio de Janeiro), the work was titled "Index para a inclusão: desenvolvendo a aprendizagem e a participação nas escolas" and has been gaining prominence in Brazil, being used in different realities and contexts beyond the school.

Santos, Silva, Pinto & Lima (2017) state that the work with the Index, whether in its development or as a theoretical-practical reference, has become a reference in Brazil and point out that:

> it is a rich document that allows for reflections on the construction of cultures, the development of policies, and the orchestration of inclusive practices in education institutions (or in groups/teams, for example, that are in search of revising their values, intentions, and actions). The Index, therefore, is a set of materials, as defined by Booth; Ainscow (2011), with the potential to support a process of self-review of schools towards the enhancement of learning and participation of individuals within it. (Santos *et al*., 2007, p. 2, our translation).

The Index presents three main dimensions, which can be better observed in Figure 1, subdivided into two others: each, and together they can lead to a possible planning structure for the development of inclusive actions in schools and society.

Figure 1: The three dimensions of the Index

Source: (Booth & Ainscow, 2011, p. 13)

Santos *et al*. (2017) postulate that cultures refer to the shared values and beliefs practiced by the actors in the inclusion process that guide policies and practices. Policies refer to agreements, legal determinations, and intentions and plans that encourage and permeate actions. Practices, on the other hand, involve the actions themselves aimed at minimizing barriers to learning and participation for all in the school environment and should be supported by cultures and policies.

In this work, we will direct our discussions on the dimension that addresses the importance of inclusive practices, mainly because we believe that schools and society need to advance in the right to the permanence, active participation, and learning of students with disabilities in the classrooms. This dimension refers to the construction of *curricula* for all and the development and improvement of what is taught and learned, and how it is taught and

learned, in a way that reflects inclusive values and policies (Booth & Ainscow, 2011). In other words, it means that the development of inclusive practices involves a collaborative and institutional model of action, since alone, the teacher does not have the autonomy to modify the pedagogical political project of the school and thus, transform a *curriculum* historically thought of in "normality" into one that values and respects difference as a premise.

When we think about pedagogical practices that can cater to everyone, we have in mind the development of a planning that can bring equity and equal learning conditions to the classroom. In this sense, students with Visual Impairment (VI), for example, require Assistive Technology (AT) resources and, above all, physical, structural, attitudinal, and pedagogical accessibility in classes, such as: texts in braille or in enlarged format, audio materials, accessible digital resources, and, whenever possible, tactile models that allow for the materialization of concepts and procedures inherent to the development of the content. Furthermore, it is necessary to use strategies that enable involvement and participation in classes, appropriate themes and contexts, and methodologies that allow the student to express themselves in classes and evaluations, respecting their needs. In clearer terms, access to the *curriculum* must be through flexible approaches, adjusted to individual and collective needs, with appropriate problematization and meaning-making, using multiple strategies and resources. Given this, following this path, our beliefs and expectations lead us to the principles advocated and supported by Universal Design for Learning (UDL) (Cast, 2011), the theoretical and methodological framework of this work, which we will discuss further ahead.

Therefore, the aim of this work is to discuss and reflect on the principles of UDL and the development of inclusive pedagogical practices, considering the presence of students with Visual Impairment in Mathematics classes. It is important to mention that this scientific exploration is of a qualitative, theoretical-practical nature, supported by a literature review, anchored by the ideas of action research, and the pedagogical practices of its author in working with students with VI. Theoretical frameworks were employed in dialogue with specialized literature to support our actions and analyses, and the activities were applied in a concurrent Professional High School class, with five students with VI. The students were all adults, aware of and in agreement with the research activities, which were monitored through photographic records and a diary. The research is part of the actions of the research group Teaching and Learning of Sciences and Mathematics for students with Visual Impairment, which had its activities approved by an ethics committee designated by the Brazil Platform under number CAAE: 46688821.4.0000.5246.

According to Hugon (1988) as cited by Barbier (2002), "action research has a dual objective: to transform reality and to produce knowledge related to these transformations" (p. 13, our translation). The research has an experimental character, with methodological rigor based on academic reports, and required a change in the subjects' attitude towards their reality, as it sought to place students as authors of their own learning. It also favored affectivity, listening, maturation, and the moment of discovery, involving all students in search of critical and reflective actions in the teaching and learning process.

As for the results, it is emphasized the importance of a critical approach to contemporary themes and of interest to students, aiming to increase engagement, highlighting the importance of presenting and using different formats of teaching materials, diversified pedagogical strategies, and establishing interrelationships between content and students' knowledge/skills during classes. Additionally, it demonstrates the need to break paradigms regarding assessment instruments, in order to enable students to express their knowledge, respecting their specificities, through the use of different assessment instruments. This translates into enabling

students to express themselves in different ways, with the traditional printed test model being just one of these forms and not the main/only one. The strategies and principles of UDL enabled self-involvement, the establishment of affective networks, motivation for classes, and a certain dynamism to the proposed activities, aiming for the participation of all students, corroborating with what different authors advocate for Universal Design for Learning as a possible path (Nunes & Madureira, 2015, Zerbato, 2018, Zerbato & Mendes, 2018, Góes, Stellfeld, Góes & Guérios, 2023).

2 Contextualizing the Investigation

At its core, the educational approaches for students with VI align with those for all students, as utilizing diverse strategies and employing tailored resources and materials for individual, collective, and curricular needs are cornerstones of an education grounded in critical thinking, reflective practices, and active participation. The student with VI, who does not have other cognitive impairments, has their learning capacity preserved, provided that appropriate teaching conditions and strategies are implemented. In this regard, we speak of the use of the Braille system, when possible, of enlarged and/or contrasting letters in the materials provided, graphotactile materials, in three dimensions (3D), in relief, in audio, or in accessible digital format, since in this multiplicity of approaches, one of them will meet the needs of these students in terms of accessing content. Another essential action in the education of students with VI, especially from the final years of elementary school, is the use of digital resources, especially cell phones and computers, since these, like other students, use this resource autonomously and have these instruments as allies in their daily activities. Screen readers, native apps on the operating systems of all phones, which can also be used on computers, allow access to websites and apps that provide people with VI access to information, communication, education, culture, and social networks.

According to Radabaugh as cited by Bersch (2017), technology, especially Assistive Technology, makes things easier for people without disabilities, but for people with disabilities, it makes things possible. Thus, we highlight the use of digital resources as imperative in the education of these students, especially because, without them, teaching activities can prove inaccessible.

In Table 1 below, we present the profile of the five students with VI who were part of this investigation and who were fundamental for us to seek pedagogical strategies that were capable of offering not only access to the school *curriculum* but also the opportunity to participate more actively in the proposed activities.

Table 1: Profile of the Research Participants

Jorge	He is 43 years old and was concurrently enrolled in a Professional High School while pursuing a Bachelor's degree in Business Administration at a Public University. He lost his vision as an adult and is not familiar with Braille, therefore he cannot read or write using this system. He has a wealth of life experience and his cell phone is his constant companion, as he uses it with ease for almost everything he does (navigation, transportation apps, food, entertainment, and communication).
Raquel	She is a little over 20 years old, congenitally blind, and reads and writes fluently in Braille. Epitomizing dedication and hard work, she

	rises at 4 a.m. to make her way to school. She navigates cell phones and computers with ease.
Davi	A 17-year-old youth with low vision and immense potential. He is not exactly sure why he chose the vocational technical course and wishes to take the ENEM (Brazil's National High School Exam). He requires a more challenging approach. He is adept at using a cell phone.
Júlia	She is a little over 20 years old, congenitally blind, and has been a student at a specialized institution since childhood, clearly with other impairments. She uses the Braille system fluently. She wakes up around 4 a.m. to get to school and only returns home in the early evening due to the distance separating her from school. She is adept at using a cell phone/computer, listens to podcasts daily, loves music, sings, and plays various instruments.
João	He is a little over 40 years old, congenitally blind, but did not have the opportunity to learn Braille, which only happened when he enrolled in the Professional High School. Despite having been out of school for several years, João has a strong passion for music and plays several instruments. He is adept at using his cell phone, employing voice assistants for nearly everything, and has become accustomed to artificial intelligence applications that assist him in numerous daily tasks.

Source: Research data

The profile of the students was the driving force behind the search for pedagogical and methodological alternatives to better meet individual needs, without disregarding the collective and curricular aspirations of a vocational high school course. Upon initial analysis, we discovered that individualistic strategies would lead to fragmentation within the group and in the mathematics content to be covered, particularly given the significant differences in student profiles. Thus, it would be difficult to meet Davi's expectations, who brings with him a good baggage of content, likes to be challenged, and wishes to attend a university, with the demands of João, who has many gaps in his educational history and still does not master a writing system that allows access to educational content. The same is true for Jorge and Julia. The former is already attending university and brings to the classroom discussions from there, not only as a way to encourage others but also seeking help for the challenges that a university course imposes on a blind person. Júlia, on the other hand, focuses on the needs of her vocational course and sees mathematics as merely a complement to her training. This leads her to complete the proposed tasks and activities with minimal effort.

In this context, we initially embraced the idea of curriculum differentiation and diversification, as it seemed to us an important aspect for achieving the inclusion and education of all. Roldão (2003) evaluates the concept of curricular differentiation and diversification based on three aspects, namely: a) Political level – differentiation in the organization of the system and schools; b) Organizational level – differentiation of levels of requirement within the same *curriculum*, and, c) Pedagogical-curricular level – which concerns the differentiation of strategies, paths, and modes of organization of teaching and learning work in the face of common learning. In this work, we base ourselves on the third aspect and the conceptions of Plestch, Souza, and Orleans (2017), who consider curricular differentiation as the modifications and strategies organized by teachers, whose objective is to meet the specific demands of students in the learning process.

As noted by Plestch *et al*. (2017), differentiations "are not associated with the limitation, annulment, or impoverishment of the contents or objectives to be proposed to the student; but rather with the revision of strategies and technological resources used so that the student with a disability can participate in educational proposals" (Plestch *et al*., 2017, p. 271, our translation). Thus:

> it's not about developing another *curriculum*, but rather working with the one that is adopted, making the necessary adjustments to it (flexibility in objectives, content, teaching methodology, timing, and assessment practices) in order to provide everyone with true equality of opportunity to build knowledge. (Carvalho, 2008, p. 105, our translation).

These conceptions led us to (re)discover UDL as a teaching strategy that allowed us to meet general, but also specific needs, as we will see next. Therefore, it is about pointing out the results of this work as possible paths that assist teachers in making their planning and pedagogical practices responsive to individual needs, considering the limitations and valuing the potentials of students, using universal strategies with multiple approaches, enabling students with disabilities to take center stage.

3 Universal Design for Learning

UDL is a concept grounded in knowledge derived from research and practices across various fields, including education, developmental psychology, cognitive science, neuroscience, and Universal Design. It is a concept attributed to David Rose, Anne Meyer, and their colleagues at the Center for Applied Special Technology (CAST), a non-profit educational research and development organization supported by the US Department of Education. The concept emerged in the late 1990s, inspired by the concept of Universal Design, which aims to eliminate architectural barriers (Cast, 2011). UDL has been used worldwide with the aim of making learning more inclusive through a polycentric approach, where everyone in the school must act to ensure access to curricular content for all students, especially those who differ in terms of motor, intellectual, sensory, and cognitive abilities (*not disabilities*).

UDL takes into account the teaching and learning process, seeking to understand how people learn, individual differences, and the strategies needed to address diversity. It presupposes the need for planning to consider the relationship between objectives, the school *curriculum*, student characteristics, learning facilitation strategies, and educational technologies that can promote accessibility to content and activities proposed in the classroom. Based on Quaglia (2015), this approach does not involve a set of new pedagogical techniques "[...] but instead organizes, synthesizes, and develops existing practices that experienced teachers already use regularly in their classrooms" (p. 2, our translation).

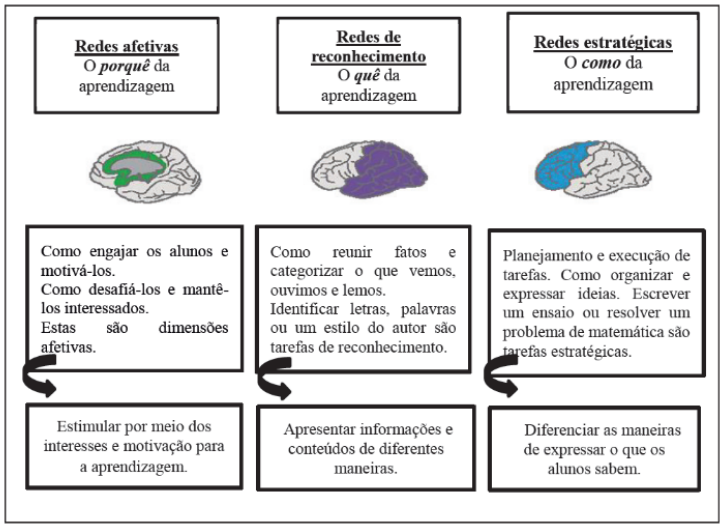
In general terms, UDL aims to develop lesson plans and didactic sequences that take into account the diversity of the classroom, considering what students learn, how they learn, and why they learn. It goes beyond access to the classroom, as it suggests the use of resources suitable for students' learning needs to access the *curriculum* and other school activities. Thus, its principles involve defining educational objectives that balance the use of strategies, educational resources, and different forms of engagement, representation, and expression relevant to all students. Therefore, it is not about thinking about usual practices of curricular adaptation or some specific activity for certain students in special education but rather about ways to make the *curriculum* accessible. Unlike adaptations, different and varied ways of

teaching are planned to respond to the characteristics and needs of all students (Zerbato & Mendes, 2018; Nunes & Madureira, 2015; Cast, 2011).

According to Cast (2011), the UDL approach was designed to understand how people learn, individual differences, and the pedagogy needed to address those differences. Nunes and Madureira (2015) highlight that the principles of UDL were influenced by knowledge resulting from studies and research in neuroscience, especially those involving learning-related systems, as learning provides a solid foundation for understanding how the brain learns. As advocated by the authors, this knowledge shows that "learning is a multifaceted process involving the use of three basic systems, namely: affective networks, recognition networks, and strategic networks, each corresponding to a particular location in the brain and having specific functions" (Meyer, Rose & Gordon, 2014, cited in Nunes & Madureira, 2015).

As outlined by Rose and Meyer (2002) as cited by Zerbato and Mendes (2018), learning is enhanced by challenges and inhibited by threats, meaning that individuals need both stability and challenge. These aspects are based on studies of three major cortical systems involved in learning, as shown in Figure 2 below:

Figure 2: Universal Design for Learning Strategies Aligned with Learning Networks



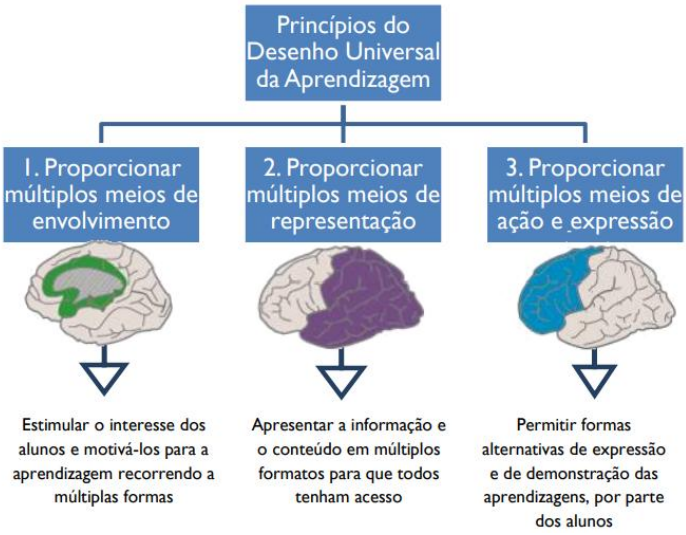
Source: (Zerbato & Mendes, 2018, p. 151)

The affective networks relate *to motivation* for learning and can be activated through teaching proposals that make use of real contexts, themes, and projects that are within students' reality, as well as stimulating their interest with different levels of challenges and opportunities for interaction in various learning contexts. The recognition networks refer to what *we learn*, while the strategic networks relate to *how we learn* and indicate how to do things. Therefore, it is not about a pedagogical preference or a teaching model, but rather about the need to renew practices (Cast, 2011).

Nunes and Madureira (2015) highlight that, according to neuroscience, these three networks do not function the same way in all people, so some may have more capabilities in the recognition networks, while others may have more facilities in the affective networks. Thus, in recognition of individual differences and with the aim of ensuring that all students have access to the common *curriculum*, Cast (2011) developed three principles that provide guidance to educators on how to make lessons more accessible (Cast, 2011, Domings, Crevecoeur & Ralabate, 2014; Meyer *et al*., 2014), as shown in Figure 3.

The first principle (Engagement) acknowledges that motivation plays a crucial role in learning and recognizes that students differ in their interests and how they can be engaged and motivated to learn. The second principle (Representation) is translated into the teaching itself. The greater the possibilities of presenting new knowledge, the greater the possibilities of learning it. It refers to pedagogical strategies that support the presentation of content and information since the way information is presented to students can expand or limit their knowledge. Finally, the third and no less important (Action and Expression) refers to planning, task execution, and evaluative processes: how to organize, express ideas, and use strategies through flexible models at all stages, especially in evaluations. In other words, it suggests that the teacher provides relevant, continuous feedback and flexible opportunities for assessment. It is important to give students the opportunity to demonstrate what they know through differentiated activities or creations, which may include physical actions, means of communication, object construction, written, artistic production, among others (Cast, 2011).

Figure 3: Principles of UDL



Source: (Nunes & Madureira, 2015)

4 From Theory to Practice: Results and Discussions

In accordance with Cast (2011), the word Universal refers to a *curriculum* that can be accessed by all, as each student brings with them experiences, skills, needs, and interests. Given this, the *curriculum* is expected to offer learning opportunities. However, learning does not occur equally, as some students are more visual, others prefer information through texts, and there are those, for example, who access information and acquire knowledge through audio, such as Podcasts, which have become popular in recent years. Regardless of the format in which the content will be presented/transmitted, the first principle of UDL refers to the importance and necessity of generating "Engagement" in the classroom.

In our interpretation, this principle translates into activities that enable all students to participate in discussions. It involves using mathematics (in our case) as a means and not an end. It refers to the importance of initiating discussions with an important theme, of interest to the students, a contemporary theme and/or of social urgency, in order to involve everyone in a seemingly unpretentious chat, initially, regarding the content itself. It does not involve a set of new pedagogical techniques "but instead, it organizes, synthesizes, and develops existing practices that more experienced teachers already use regularly in their classrooms" (Quaglia, 2015, p. 2, our translation).

Booth and Ainscow (2011) emphasize the importance of linking learning to experiences, both local and global, as well as to rights. From their perspective, "learning is orchestrated so that teaching and learning activities become responsive to the diversity of young people in the school" (p. 46, our translation). Students should be encouraged to be active, reflective, that is, critical learners. For this to happen, the teacher must somehow subvert tied, predetermined, and traditionally organized *curricula*. Acting in this perspective translates into (re)thinking the *curriculum* based on work with global themes, as suggested by Booth and Ainscow (2011), in the Table 2 below:

Table 2: Rights-Based Curriculum

(Re)thinking the School *Curriculum*	
***Curriculum* Based on Global Rights**	**Traditional *Curriculum***
Food, water, and clothing Housing/construction Transportation, health, and relationships Environment and energy Communication and Communication Technology Literature, arts, and music Work and activity Ethics, power, and government	Mathematics Language and Modern Literature Foreign Languages Physics, Chemistry, and Biology Geography and History Drawing and Technology Art, music, and religion Physical Education

Source: (Booth & Ainscow, 2011)

In line with these guidelines, to embark on studying exponential functions with the class, we opened our discussion by inquiring about their prior knowledge of exponential growth and decay, and whether they had encountered this topic in their previous studies. Davi said he had already studied the subject and cited *credit card interest rates* as an example. According to him, *unpaid debts grow very rapidly, in an exponential manner*. We asked the others what they thought about the statement, and everyone agreed without further comments. We continued our conversation by presenting other examples and situations of exponential growth, such as cell multiplication in the human body over a certain period of time, and the growth of a particular species/population, often modeled by exponential functions. We also cited the advancement of technology as an example, explicitly stating the processing power of computers over the years, a fact described by Moore's Law, which has driven the technological revolution since it was proposed in 1965. The topics caught everyone's attention, with at least one student intervening in each of the examples mentioned, bringing their opinion and/or knowledge on the subjects. Regarding the "computer processing power" related to Moore's Law, it was observed that this doubled every two years, justifying its exponential growth.

Jorge, for instance, became interested in the topic and commented that Moore's Law should no longer be considered true because, as he himself asserts, *changes in the world of computing occur at a much faster pace, and countless new discoveries are shared every day*. In this context of technology, Raquel mentioned that she uses an app to recognize the colors of the clothes she wears and identify objects through artificial intelligence, and that she uses the app almost daily, thus expanding the discussions. The reflections continued when Davi remarked that exponential growth seemed like a common occurrence in everyday life, as exemplified by the various examples we discussed. However, he couldn't recall any everyday examples that

could be related to exponential decay. We passed the question back to the class, which remained silent, without recognizing a situation where exponential decay was evident.

In response to Davi's question, we can cite the depreciation of cars and equipment as examples that can be modeled by decreasing exponential functions. Newton's Cooling Law states that when an object is cooled, its temperature decreases exponentially over time. Another example discussed with the students was the decay of alcohol content in the blood after ingestion: a theme that soon broadened and diverged into the topic of "Dry Law." The class became interested in the topic, so we discussed alcohol consumption, traffic accidents, and the imprudence of drinking and driving. According to João, *people who drink, drive, and cause accidents should be imprisoned because a fine alone doesn't solve the problem*. Regarding alcohol consumption, we discussed how each individual's body metabolizes ingested ethanol at different rates, but there are scientific data indicating an approximate decay rate of 20 mg/dL per hour. As for individuals who chronically use alcohol, this rate can increase to approximately 30 mg/dL per hour, situations that can be modeled by decreasing exponential functions.

The importance of Statistics in daily life, census research, market recognition for trade and industry, as well as the quality control of products and services, can be triggering themes for engagement and participation when introducing Statistics content, for example. These discussions fostered engagement and collaboration, enabling everyone to participate in class discussions about this body of knowledge. Following the same path, we used as a triggering theme for working with Financial Mathematics the scams highlighted by the media involving cryptocurrencies and investments promising above-average profits and easy gains. We started this conversation by asking what the students knew about these topics and how they had access to this information in their daily lives, thus provoking valuable moments of debate on the subject. Everyone said they had heard about the topic and the existence of bitcoins, but no one knew how cryptocurrencies would be part of society's daily life, a theme still distant from their realities.

The presentation of textual material, with a focus on introducing concepts, definitions, and examples, is the second step in this process. Here, the importance of providing the material in an enlarged format, in Braille, in audio, and in accessible digital formats is highlighted, especially considering the profile of the class (Table 1). In situations involving Financial Mathematics, our textual material contained the most common terms used in the economic field (interest rates, central bank, stock exchange, savings, fixed and variable income, among others), concepts of inflation, and the main financial indicators circulated by the media when the subject is economics. We provided a Podcast episode, recorded by the author himself, containing the main concepts, definitions, and terms related to the cryptocurrency theme, shared through WhatsApp, a social network frequently used by the class, through a messaging group created for this purpose.

As observed by Góes *et al*. (2023), there is no defined order for using the principles of UDL, as these can be employed with different strategies, whether combined or not, considering the specific learning objectives. Another aspect, as per the authors, is the non-compulsion to use all guidelines in a single learning activity, as these depend on the defined objectives. In the mentioned situations, the provision of materials in different formats is anchored in the second principle, that of multiple representations, as this enables respect for the needs and specificities of the students. To illustrate, João, who became blind in adulthood and does not regularly use the Braille System, prefers to access activities through accessible digital files (to be read by screen readers). According to him, he has a preference for audio content because he is a frequent user of such content*: I subscribe to and follow various channels and digital influencers,*

professor. The third principle, that of action and expression, is evident in these approaches when students are enabled to participate in classes by sharing their insights on the topics discussed, thus generating a debate in the classroom. They bring their experiences, present their knowledge (or lack thereof) on the topics, and offer to conduct research to contribute to the discussions. To exemplify, Júlia and João use artificial intelligence to perform tasks and research daily. They use apps to carry out various daily tasks and enjoy being challenged with research on topics that the class does not master. Therefore, allowing students to bring their experiences is a way to offer them the opportunity to actively participate in discussions.

The situations described above affected the affective functions of the students, motivated the class, and provided meaning to learning. They represent and translate into the "why" of learning because motivation plays a relevant role, recognizing that students differ in their interests and in how they can be engaged and motivated to learn (Courey, Tappe, Sike & LePage, 2012). The use of different examples and situations, access to content in different formats, and the possibility of active participation in discussions are all anchored in the three principles of UDL.

Although there is no hierarchy in how we should appropriate UDL for teaching activities, the relevance of the principle of multiple representations for students with visual impairments stands out, as textual materials commonly used in schools, through lists, workbooks, and/or textbooks, are not accessible to these students. In this sense, the need to offer content in different formats to reach the greatest number of students, whether they have disabilities or not, becomes urgent. Thus, we interpret this second principle as being the act of teaching itself. The greater the opportunities for presenting new knowledge, the greater the possibilities of learning it, and this aligns with the different pedagogical strategies we should use, as the way information is presented to students can either expand or limit their knowledge (Zerbato & Mendes, 2018).

We consider the second principle, that of multiple representations, as the need to present students with visual impairments with different ways to access content. This principle presupposes the need to address the relationship between the objects of knowledge, the objectives, the characteristics of the students, the facilitative learning strategies, and the available educational technologies. So, we emphasize the importance of using concrete materials, materials in digital format (accessible), texts in Braille and in enlarged format, content through audio, tactile materials, and graphotactile materials whenever possible. Figure 4 below presents three images of different situations in which multiple representations were used in the approach to content in the classes. The first option, on the left, consists of audio files shared in podcast format. The second one presents adapted Braille content, essential for blind students who are proficient in the system. The third one on the right refers to the sharing of accessible digital files through WhatsApp.

Figure 4: Multiple Representations of Content

Source: Research Data

Figure 5, below, presents images of graphotactile materials, concrete materials (in 3D), with relief and information in braille and in ink (enlarged), also with the intention of providing accessibility to the content.

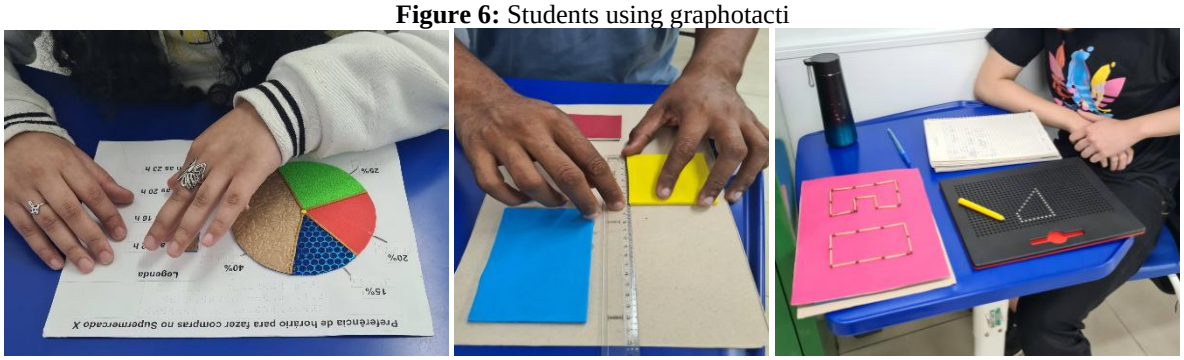
Figure 5: Handcrafted graphotactile materials

Source: Research data

The feedback on this type of approach is always very positive, as students feel included in their different ways of accessing content and have their accessibility rights met. Regarding the sharing of materials through digital means, this has become popular among students (with and without visual impairments) and is a reality in schools, especially after the pandemic period that expanded remote activities. Social media is also part of the daily routine of students with visual impairments, and content shared via WhatsApp (or email) allows them to choose the best time to access materials, organize, and study autonomously outside of school. According to Nelson (2013), it is important for students to have diversified experiences, time, and opportunity to explore knowledge beyond the classroom, as such knowledge and connections cannot stagnate. Furthermore, as reported by to the author, learning must make sense to everyone, so that information is related and interconnected with the learner, otherwise there is a risk of memorization, not learning.

Each individual is unique, and consequently, each one has unique needs, expectations, demands, and modes of learning, which makes the multiplicity of approaches, combined with contemporary themes, have a greater chance of reaching a larger number of students. Zerbato and Mendes (2018) point out that "there is no recipe that can be followed for teaching all students – after all, this would imply the homogenization of teaching and a return to traditional educational practices, a path contrary to the practice of the principles of school inclusion" (p. 152, our translation). Furthermore, the UDL does not propose the use of a single approach strategy to meet everyone's needs, as this is impractical in a classroom characterized by diversity. In this sense, we advocate for global themes as motivational, but the use of resources tailored to individual needs that may exist in the classroom. Figure 6 below shows students using graphotactile resources, materials with relief, and adapted instruments (ruler with relief markings). It is worth mentioning that it is not about offering a different material for the student with a disability or adapting something for them, but rather enabling them to access the same material as everyone else, but meeting their needs.

Figure 6: Students using graphotacti



Source: Research data

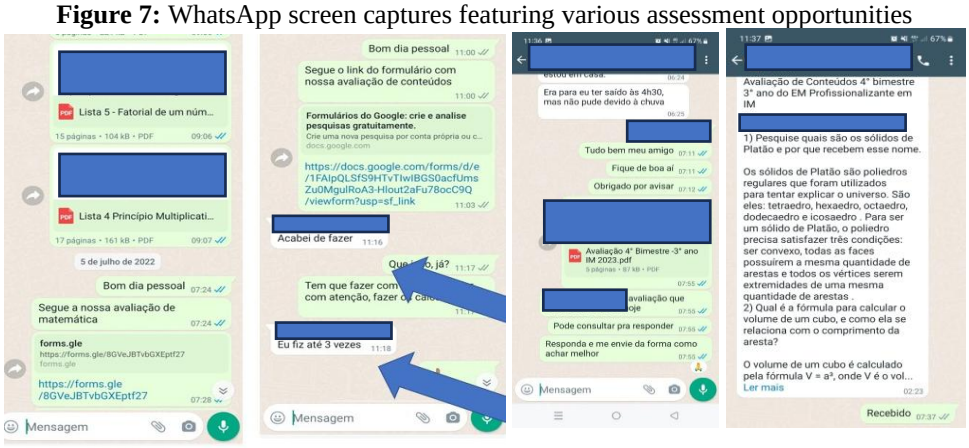
A point that draws attention in the inclusion process of students in Special Education is the assessment of school performance. In research with students with visual impairments (VI) included in regular mainstream schools, Bernardo (2021) and Rosa (2017) point out that many of these students are subjected to the same assessment instruments used with non-disabled students, resulting in a homogenized process in the school. However, the authors mention a impoverishment of content in these instruments, with a level of difficulty well below that used with non-disabled students, and theoretical questioning. To address the eventual needs of students, the authors mention the offer of extended time for taking exams by educational institutions.

This scenario creates a feeling of segregation in the student and causes their results and grades—even if above average—to not have the same "value" as the same grade received by a student without disabilities, since everyone knows that the tests are different and, above all, easier. Thus, traditional evaluation becomes another instrument of differentiation and provokes a feeling of low self-esteem in the blind student, who often only needs accessibility and adequate conditions to learn and demonstrate what they have learned.

Taking into account the evaluation process, the third principle of UDL, that of action and expression, contributes to the importance of offering students different ways to express their knowledge, largely because the use of UDL must occur in a procedural manner (Góes *et al*., 2023), that is, evaluation must occur throughout all stages of teaching. In addition, the principle of action and expression seeks to value the potential of students and what they are capable of doing, instead of forcing them to fit into a predefined, standardized, and homogeneous model, which ends up excluding many students. So, in our investigation, we seek to make the evaluation process more equitable by offering students a multiplicity of ways to express their knowledge. This translates into the possibility for them to choose and use different assessment instruments, but without abandoning traditional instruments, such as written tests, as long as they are provided in enlarged print and braille, in digital format, or through audio, to meet their needs. There is also the possibility of using Google forms, which have also become popular during and after the pandemic period, as screen readers can read the content of the form.

Figure 7 below presents two examples of assessment instruments that can be used to make tests more equitable in schools: the first two (on the left) demonstrate the use of Google forms, with a link shared via WhatsApp; the other two (on the right), the possibility for the student to both receive and return the assessment in digital format.

Figure 7: WhatsApp screen captures featuring various assessment opportunities



Source: Research data

In addition to the digital format, students were able to complete the same assessment tasks in the classroom itself, as these were also provided in print, with enlarged letters, and in braille for those who preferred it. Zerbato and Mendes (2018) suggest "a variety of assessment methods (for example, through articles, learning journals, presentations, tests, questionnaires, oral exams)" (p. 153, our translation), so that this occurs throughout the teaching process, whether in the bimester or trimester. Furthermore, they emphasize the importance of providing opportunities to complete a task in different formats, such as through artistic presentations, in pairs or groups, through videos, audios, and other available means in the school environment, as this process allows for respect for individualities without seeking to exclude students or view disability as an impediment.

In light of all the above and in line with the ideas advocated by authors who support the use of UDL, we consider that the assessment of learning should be sufficiently flexible to allow for systematic and continuous observation of students' progress. It is essential to understand individual progress, as this is an unequivocal right that needs to be preserved, under the risk of reinforcing ableist attitudes within the school environment by highlighting disability at the expense of students' abilities.

5 Final Considerations

Ensuring access to school is the easiest dimension to achieve in the inclusion process, as it depends primarily on political decisions, and this seems to have been one of the greatest advances of Brazilian society in recent years, even at the expense of tireless struggles, societal pressures, and the protagonism achieved by people with disabilities, who will now occupy prominent positions in society. However, guaranteeing the right to remain and learn involves significant transformations in how we conceive the role of the school and the teacher in the teaching and learning process, as well as coordinated actions from all of society, in order to rethink values, rights, and duties. According to Nunes and Madureira (2015), it is therefore "about equating inclusive pedagogical processes that allow the effective involvement of children and young people with Special Educational Needs in learning" (p. 7, our translation), which can be favored by Universal Design for Learning, both as a methodological approach and as a theoretical framework.

Our investigations highlight the importance of offering a more universal *curriculum*, accessible to all, recognizing the diversity of experiences, abilities, and interests of students. The first principle of UDL, related to "Engagement", emphasizes the need to initiate discussions with relevant themes of interest to students, using mathematics as a means to explore global

issues (Booth & Ainscow, 2011). This approach, instead of introducing new pedagogical techniques, seeks to organize and synthesize existing practices, promoting active participation by all in the classroom.

The second principle, that of "Multiple Representations", emerges as important to meet the specific needs of students with visual impairments. The diversification of formats, such as audio, Braille, accessible digital material, and tactile materials, allows each student to access the content in a way that is appropriate to their preferences and needs. The third principle of UDL, "Action and Expression", is approached from the perspective of inclusive assessment. The emphasis is on the importance of offering different forms of knowledge expression, ensuring that students with visual impairments have equal opportunities to demonstrate their learning. Flexibility in assessment formats, such as the use of digital forms and consideration of each student's particularities, emerges as a fundamental practice. In this sense, the discussion about assessment highlights the need to avoid differentiations that diminish the value of results for students with disabilities, ensuring that assessment is fair and respects individual potentials. The flexibility and diversity of assessment methods, such as artistic presentations, group projects, and oral exams, are presented as strategies to ensure equity in the process.

In conclusion, the application of the UDL principles presented in this study goes beyond the inclusion of students with visual impairments; it promotes a broader pedagogical approach that is open to diversity. By emphasizing engagement, diversification of representations, and flexibility in assessment, the educational proposal seeks to meet individual and collective needs, fostering a more inclusive, participatory, and meaningful learning environment.

References

Barbier, R. A. (2002). *Pesquisa-ação*. Tradução de L. Didio. Brasília: Liber Livro.

Bernardo, F. G. (2021). *As experiências e práticas curriculares inclusivas no ensino de Matemática para alunos com deficiência visual em uma escola pública na cidade do Rio de Janeiro: vivências e percepções de alunos e professores*. 292 f. Tese (Doutorado em Ensino e História da Matemática e da Física). Instituto de Matemática, Universidade Federal do Rio de Janeiro, RJ.

Bersch, R. (2017). *Introdução à tecnologia assistiva*. Assistiva, Porto Alegre.

Booth, T. & Ainscow, M. (2011). *Index para inclusão: desenvolvendo a aprendizagem e a participação na escola*. (3. ed.). Tradução de Mônica Pereira dos Santos. Rio de Janeiro: LaPEADE.

Carvalho, R. E. (2008). *Escola inclusiva: a reorganização do trabalho pedagógico*. Porto Alegre: Mediação.

Center for Applied Special Technology (CAST). (2011). *Learn about universal design for learning*.

Courey, J. S., Tappe, P., Sike, J. & LePage, P. (2012). Improved lesson planning with universal design for learning (UDL). *Teacher Education and Special Education*, *36*(1), 7-27.

Domings, Y., Crevecoeur, Y. C. & Ralabate, P. K. (2014). Universal design for learning: Meeting the needs of learners with autism spectrum disorders. In K. I. Boser, M. S. Goodwin & S. C. Wayland (Orgs.), *Technology tools for students with autism: Innovations that enhance independence and learning* (pp. 21-41). Baltimore: Paul Brookes Publishing.

Diniz, D., Barbosa, L. & Santos, W. R. dos. (2009). Deficiência, direitos humanos e justiça. *Revista Internacional de Direitos Humanos*, *6*(11), 65-77.

Góes, H. C., Stellfeld, J. Z. R., Teixeira Góes, A. R. & Guérios, E. C. (2023). Aproximações entre o desenho universal para aprendizagem e o pensamento complexo em prática de educação matemática inclusiva. *Revista Sergipana de Matemática e Educação Matemática*, *8*(2), 289-308.

Meyer, A., Rose, D. H. & Gordon, D. (2014). *Universal design for learning: Theory and practice*. Wakefield: CAST Professional Publishing.

Nunes, C. & Madureira, I. (2015). Desenho universal para a aprendizagem: construindo práticas pedagógicas inclusivas. *Escola Superior de Educação do Instituto Politécnico de Lisboa da Investigação às Práticas*, *5*(2), 126-143.

Pletsch, M. D., Souza, F. F. & Orleans, L. F. (2017). A diferenciação curricular e o desenho universal na aprendizagem como princípios para a inclusão escolar. *Revista Educação e Cultura Contemporânea*, *14*(35), 264-281.

Pletsch, M. D. (2020). O que há de especial na educação especial brasileira? *Momento - Diálogos em Educação*, *29*(1), 57-70.

Quaglia, B. W. (2015). Planning for student variability: Universal design for learning in the music theory classroom and curriculum. *A Journal of the Society for Music Theory*, *21*(1), 1-21.

Roldão, M. do C. (2003). *Diferenciação curricular revisitada: conceito, discurso e práxis*. Porto: Porto Editora.

Rosa, F. M. C. (2017). *Histórias de vida de alunos com deficiência visual e de suas mães: um estudo em educação matemática inclusiva*. 259 f. Tese (Doutorado em Educação Matemática). Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista "Júlio de Mesquita Filho" – Unesp, Rio Claro, SP.

Santos, M. P., Silva, M. R. P. S. V., Pinto, R. M. S. C. & Lima, C. B. (2017). Desenvolvendo o Index para Inclusão no contexto brasileiro: experiências de reflexão/ação sobre processos de inclusão e exclusão em educação. *Percurso Acadêmico*, *7*(14), 332-350.

Zerbato, A. P. (2018). *Desenho universal para aprendizagem na perspectiva da inclusão escolar: potencialidades e limites de uma formação colaborativa*. 298 f. Tese (Doutorado em Educação). Universidade Federal de São Carlos, SP.

Zerbato, A. P. & Mendes, E. G. (2018). Desenho universal para a aprendizagem como estratégia de inclusão escolar. *Revista Educação da UNISINOS*, *22*, 147-155.