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Assistive digital technologies in science and mathematics education: a systematic review from the UDL perspective

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ABSTRACT

This study analyzes the use of Assistive Digital Technologies (ADTs) and the application of Universal Design for Learning (UDL) in science and mathematics education, based on a Systematic Literature Review (SLR). The problem that guides the investigation is the scarcity of systematic studies that articulate ADTs and UDL in basic and higher education, especially in science and mathematics. The research is grounded in the principles of UDL (engagement, representation, and action/expression) and in normative documents, such as the Brazilian Inclusion Law (Law No. 13,146/2015), Decree No. 10,502/2020, and Resolution CNE/CP No. 2/2019, in addition to the National Common Core Curriculum (BNCC, 2018). Eleven relevant studies were selected and organized into three analytical categories: Universal Design for Learning and Educational Equity, Teacher Training Development, and Assistive Digital Technologies. The analysis revealed gaps, including a lack of research on the practical implementation of UDL in different contexts and the absence of longitudinal evaluations. The results indicate that continuing teacher training, structured pedagogical planning, and technological infrastructure are determining factors for effective inclusive practices. It is concluded that the integration of UDL, ADTs, and teacher training is an essential component for effective inclusive and equitable education.

KEYWORDS: Assistive Digital Technologies; Universal Design for Learning; Science and Mathematics Education; Inclusion.

Tecnologias digitais assistivas no ensino de ciências e matemática: revisão sistemática sob a perspectiva DUA

RESUMO

Este estudo analisa o uso de Tecnologias Digitais Assistivas (TDAs) e a aplicação do Desenho Universal para a Aprendizagem (DUA) no ensino de Ciências e Matemática, com base em uma Revisão Sistemática da Literatura (RSL). O problema que orienta a investigação é a escassez de estudos sistematizados que articulem TDAs e DUA na Educação Básica e Superior, especialmente em Ciências e Matemática. Como fundamentação, a pesquisa se ancora nos princípios do DUA (engajamento, representação e ação/expressão) e em documentos normativos, como a Lei Brasileira de Inclusão (Lei nº 13.146/2015), o Decreto nº 10.502/2020 e a Resolução CNE/CP nº 2/2019, além da BNCC (2018). Foram selecionados 11 estudos relevantes, organizados em três categorias analíticas: Desenho Universal para a Aprendizagem e Equidade Educacional, Desenvolvimento Formativo Docente e Tecnologias Digitais Assistivas. A análise evidenciou lacunas, incluindo a carência de investigações sobre a implementação prática do DUA em diferentes contextos e a ausência de avaliações longitudinais. Os resultados indicam que a formação docente continuada, o planejamento pedagógico estruturado e a infraestrutura tecnológica são fatores determinantes para práticas inclusivas eficazes.
Conclui-se que a integração entre DUA, TDAs e formação docente constitui componente essencial para efetivar uma educação inclusiva e equitativa.
PALAVRAS-CHAVE: Tecnologias Digitais Assistivas; Desenho Universal para Aprendizagem; Ensino de Ciências e Matemática; Inclusão.

INTRODUCTION

In recent decades, school inclusion has gained prominence in Brazilian educational policies, driving debates and practices aimed at building fairer educational trajectories that ensure not only admission but also the continuous involvement and meaningful development of all students in the school context. Addressing diversity in science and mathematics education requires more than just occasional adaptations; it also requires the reinvention of pedagogical practices from an inclusion perspective. This commitment is in line with the principles of the National Common Core Curriculum (BNCC, 2018), which recognizes the right of every student to an equitable, accessible, and quality education.

In this context of seeking more equitable pedagogical practices, Assistive Digital Technologies (ADTs) play a strategic role in enhancing access to knowledge and expanding the possibilities for students with disabilities to participate in science and mathematics classes. As Ramalho and Lima (2023) point out, such technologies operate as mediators in overcoming pedagogical, communicational, and technological barriers, promoting conditions that are more favorable to the autonomy and engagement of these students in different learning experiences.

According to Sebastián-Heredero, Prais, and Vitaliano (2022), the use of these technologies becomes even more significant when integrated into a perspective that reconceives the ways of teaching and learning, by proposing flexible pedagogical strategies capable of accommodating the multiple forms of participation and expression that coexist in diverse educational contexts.

In this scenario, there is a need to understand how ADTs have been mobilized based on the principles of Universal Design for Learning (UDL), especially in the context of science and mathematics education. The scarcity of systematic studies on this articulation, coupled with the urgency of establishing truly inclusive pedagogical practices, motivated this Systematic Literature Review (SLR), whose purpose is to identify, map, and analyze strategies, resources, and challenges associated with the use of ADTs in teaching and learning processes from the perspective of UDL.

Thus, this study aims to broaden the academic and professional debate around digital and pedagogical inclusion, gathering systematic evidence that can support teachers, administrators, and researchers in the construction of educational practices that are more accessible, creative, and attuned to the contemporary challenges of school inclusion. By systematizing theoretical and methodological evidence from the literature, we aim to contribute to the strengthening of a pedagogical culture that recognizes diversity as a structuring principle of teaching.

THE CENTRALITY OF SCIENCE AND MATHEMATICS TEACHING IN SCHOOL EDUCATION ACCORDING TO THE BNCC

From the early years of elementary school, the teaching of science and mathematics occupies a strategic place in the education of critical and reflective individuals, capable of interpreting phenomena in the natural and social world based on conceptual and applied knowledge. The National Common Core

Curriculum (BNCC, 2018) recognizes this relevance, as it proposes a set of competencies and skills that link scientific and mathematical knowledge to concrete everyday situations, encouraging active understanding of reality and decision-making based on logical and investigative thinking.

In the field of Natural Sciences, the BNCC (2018) highlights scientific literacy as a structuring axis, understood not only as mastery of concepts, but as the ability to interpret phenomena, formulate reasoned arguments, and consciously intervene in current social and environmental issues. This position converges with the perspective of Lorenzetti and Delizoicov (2001) when they argue that science education should engage with the dilemmas of the contemporary world, contributing to the ethical, critical, and situated education of students in relation to their reality.

In line with this approach, mathematics is conceived, according to the BNCC (2018), as an essential language for the construction of logical reasoning, quantitative analysis, and creative problem solving. D'Ambrósio (2005) reinforces this understanding by proposing an approach to mathematics as a historical, cultural, and socially situated production, whose learning should be based on real and meaningful situations, expanding students' intellectual autonomy and protagonism in the face of the complexities of everyday life.

Complementing this view, Zabala (1998) advocates the adoption of methodologies that promote integration between areas of knowledge and break with the traditional fragmentation of school content, especially in elementary school. For the author, the learning process gains power when knowledge is presented in an articulated and contextualized way, allowing students to construct meanings that dialogue with their reality. This approach is supported by the general competencies of the BNCC (2018), which propose the articulation between scientific, mathematical, and social knowledge as a path to a more critical, reflective education that is connected to the challenges of the contemporary world.

ASSISTIVE DIGITAL TECHNOLOGIES IN EDUCATION

Given the heterogeneity present in classrooms, ADTs emerge as fundamental tools for ensuring equitable conditions of access to knowledge in the teaching of science and mathematics. Developed with the purpose of eliminating barriers to participation and learning, these technologies play a strategic role in promoting educational environments that are accessible and responsive to diversity.

Ramalho and Lima (2023) argue that ADTs go beyond compensating for functional impairments; that is, they reconfigure the pedagogical dynamics themselves by allowing adaptations of content, activities, and assessments that favor the autonomy and protagonism of students with disabilities. From this perspective, technology ceases to be a one-off resource and becomes an integral part of teaching planning, in line with the principles of inclusive education and the guidelines of the BNCC (2018).

This commitment is in line with the principles of the BNCC (2018), which recognizes the right of every student to equitable, accessible, and quality education. In addition, legal guidelines, such as the Brazilian Inclusion Law – LBI

(Law No. 13,146/2015); Decree No. 10,502/2020, which establishes the National Special Education Policy; and Resolution CNE/CP No. 2/2019, reinforce the need for educational practices guided by equity and universal accessibility.

Recent research highlights this understanding by showing that the use of interactive software, digital readers, alternative communication applications, and physical accessibility resources not only expands learning opportunities for students with disabilities but also benefits the entire group by promoting more innovative, flexible, and student-centered practices (Silva et al., 2022; Oliveira & Rocha, 2021). By integrating accessibility and pedagogical innovation, ADTs have established themselves as essential mediators between school knowledge and different ways of learning.

Despite the transformative potential of ADTs, their implementation still faces significant obstacles in everyday school life. The scarcity of technological infrastructure, the absence of continuing teacher training policies, and the disconnect between resources and the official curriculum are factors that limit their effectiveness (Siqueira, 2022).

Cunha, Leite, Santos, and Pinto (2023) and Siqueira (2022) emphasize that the effectiveness of inclusive educational technologies depends on the articulation between digital resources, public policies, and teacher training processes, pointing out that inclusion is not based solely on the availability of tools, but on a pedagogical culture that values accessibility from planning to evaluation.

These challenges indicate that the success of ADTs depends both on their availability and on a pedagogical culture that values accessibility and inclusiveness from planning to evaluation. Thus, ADTs, in addition to expanding access, also qualify learning experiences from a perspective of educational justice.

UNIVERSAL DESIGN FOR LEARNING (UDL) AS A BASIS FOR INCLUSIVE PEDAGOGICAL PRACTICES

In an educational scenario that is increasingly attentive to diversity, UDL emerges as a structuring pedagogical approach for inclusive curriculum planning. Based on the principles of accessibility and equity, UDL proposes that learning environments be designed from the outset to accommodate a plurality of ways of engaging, representing, and expressing knowledge, avoiding remedial or segmented solutions.

Its three central principles—multiple forms of engagement, multiple forms of representation, and multiple forms of action/expression—were considered in this analysis as structuring axes. These principles should not be treated as “adaptable,” but rather as “readjusted” strategies from the planning stage, preventing barriers to access and participation.

According to Sebastián-Heredero, Prais, and Vitaliano (2022), the application of UDL in science and mathematics education expands the possibilities for participation for all students—regardless of their physical, sensory, or cognitive conditions—by integrating strategies, resources, and assessment methods that respect the unique characteristics present in the classroom. By intentionally articulating varied pedagogical resources from the planning stage, UDL contributes

to the elimination of barriers to learning that have historically marginalized certain student profiles.

Recent studies (Lima, Oliveira, Santos & Souza, 2023; Costa & Nascimento, 2022) reinforce that the potential of UDL is amplified when integrated with ADTs, favoring the creation of more responsive and adaptable environments. This combination allows accessibility to extend beyond infrastructure, manifesting itself in teaching practices, materials, mediation strategies, and assessment criteria.

Replacing homogeneous teaching models with flexible and intentionally diversified practices transforms UDL into a powerful tool for the implementation of inclusive education, in line with the principles of the BNCC (2018).

Thus, UDL should not be understood as a set of isolated resources; it is a teaching paradigm committed to structural equity, active participation, and the appreciation of difference as a constitutive element of the educational process. Its adoption requires a cultural change in educational institutions, supported by training policies, teacher engagement, and pedagogical intentionality from planning to assessment.

Based on these theoretical contributions, there is a clear need to deepen our understanding of the intersection between ADTs and UDL in the specific context of science and mathematics education. The methodological procedures adopted for this systematic review, which aims to map and analyze the available evidence on this articulation, are presented next.

METHODOLOGICAL PROCEDURES

In order to understand the state of the art regarding the use of inclusive digital technologies in science and mathematics education, anchored in the UDL approach, an SLR was conducted in national and international academic databases. The methodological conduct of this review was based on the protocol proposed by Kitchenham and Charters (2007), widely referenced for its consistency and rigor in structuring systematic reviews.

To reinforce the thoroughness of the process of searching, selecting, and analyzing studies, the guidelines of Petticrew and Roberts (2006) were incorporated, focused on transparency and validity in reviews in the field of Social Sciences. In addition, the recommendations of Booth, Sutton, and Papaioannou (2019) were considered, which contribute to increasing the accuracy, traceability, and comprehensiveness of findings in interdisciplinary studies.

In this process, the objective was to identify primary studies capable of answering the Systematic Review Questions (SRQs) that guide this investigation, considering different types of academic production, such as scientific articles, dissertations, theses, books, and book chapters, in order to ensure broad and representative coverage of the relevant literature.

The definition of search terms covered the main topics related to the object of study, combining terms such as “Assistive Digital Technologies,” “Science Education,” “Mathematics Education,” “Inclusion,” and “Universal Design for Learning.”

The formulation of search strategies involved careful customization of descriptors and strategic application of Boolean operators, considering the particularities of each database consulted, with the aim of maximizing both the sensitivity and specificity of the results obtained.

Table 1 summarizes the search strings used in each of the databases selected for this review, including: CAPES, Brazilian Digital Library of Theses and Dissertations (BDTD), Web of Science, Google Scholar (using the Publish or Perish tool), and SciELO.

Table 1

Search strategies adopted in the databases

DATABASE	STRINGS
CAPES	"Tecnologias Assistivas" AND "Digitais" AND "Inclusão" AND "Ensino Fundamental"
BDTD	"Tecnologias Assistivas" AND "Digitais" AND "Inclusão" AND "Ensino Fundamental"
WEB OF SCIENCE	((All=(Inclusive Digital Technologies) OR All=(Assistive Technology)) AND (All=(Mathematics Teaching) OR All=(Science Teaching))) AND All=(Universal Design For Education)
GOOGLE SCHOLAR (Publish or Perish)	((All=(Inclusive Digital Technologies) OR All=(Assistive Technology)) AND (All=(Mathematics Teaching) OR All=(Science Teaching))) AND All=(Universal Design For Education)
SCIELO	(Tecnologia Assistiva) AND (Ensino) AND (Inclusão)

Source: Own elaboration (2025).

It can be observed that, in the CAPES and BDTD databases, the same expression in Portuguese was used, prioritizing terms combined directly by AND operators. In contrast, in the Web of Science and Google Scholar databases, greater semantic coverage was sought with the use of the OR operator for equivalent terms, as well as the All Fields to increase the scope of the searches. The strategy in SciELO was simplified to suit the indexing structure of the database.

The adaptation of the search strategy to the characteristics of each database is considered a critical factor in the quality of systematic reviews, as emphasized by Tranfield, Denyer, and Smart (2003).

In Google Scholar, the search was conducted using Harzing's Publish or Perish (PoP) tool, which allows the extraction and analysis of metadata from scientific publications. To avoid an excessive number of publications, a maximum limit of 1,000 results was applied, according to the tool's restrictions.

Due to the large volume of publications returned, a special relevance criterion based on the number of citations was adopted, considering only studies that had an H-index recorded in the tool's own database. With this filtering, 17 papers

(Google Scholar) were selected, prioritizing research with recognized impact in the academic community.

The data collected allow us to visualize the distribution of scientific production on the topic, highlighting gaps that are still under-explored in the literature and offering insights for reflection on the applicability of ADTs in the educational context. Table 2 organizes the results found in the five academic portals consulted: CAPES, BDTD, Web of Science, Google Scholar, and SciELO.

Table 2

Total records identified by database

PORTAL	DISSERTATION	THESIS	ARTICLE	BOOK	BOOK CHAPTER	TOTAL
CAPES	16	1	–	–	–	17
BDTD	6	4	–	–	–	10
Web of Science	–	–	9	–	2	11
Google Scholar	–	–	6	11	–	17
SciELO	–	–	8	–	–	8
TOTAL SEARCHES						63

Source: Own elaboration (2025).

Once the initial mapping was completed, inclusion and exclusion criteria were defined and applied to refine the selection of studies. Those that addressed the use of ADTs and/or UDL in science and mathematics education were considered eligible. In addition, academic productions with an empirical, theoretical, or qualitative basis were considered, including scientific articles, dissertations, and theses, regardless of the language of publication.

Studies that did not address the use of ADTs in science and mathematics education or discuss UDL were excluded. Publications such as editorials, prefaces, news articles, and reviews published exclusively in print format were also disregarded when their digital unavailability made full access to the content unfeasible. It should be noted that no time frame was established as an exclusion criterion in order to preserve the scope of the search and include potentially relevant works, regardless of the year of publication.

The initial screening stage consisted of reading the titles and abstracts, followed by a full analysis of the materials that met the established criteria, since the abstracts sometimes did not provide sufficient information for an in-depth evaluation. The data were then systematically organized through analytical records, developed in two distinct and complementary stages, ensuring consistency of the records and fidelity to the original content.

RESULTS AND DISCUSSIONS

The analysis of the 11 selected studies allowed us to identify recurring patterns, thematic trends, and relevant gaps in scientific production on the use of ADTs in science and mathematics education, in conjunction with the principles of UDL. This set of studies corresponds to 17% of the total initially mapped, consisting of four scientific articles and seven dissertations.

The process of organizing and describing the corpus followed four main stages: identification of research, definition of the systematization methodology, pre-analysis, and thematic categorization. In the initial stage, the works were classified in detail based on the type of publication, title, authorship, year of publication, and database in which they were located, as shown in Table 3.

Table 3

Studies included in the final corpus of the review

TYPE	TITLE	AUTHOR/YEAR	DATABASE
Article	Digital technologies as enablers of universal design for learning: higher education students' perceptions in the context of SDG4	Bucheli, M. G. V.; Mesa, M. L. C.; Galán, J. G.; Catalán, L. L. (2024)	Web of Science
	Developing an adaptive virtual learning environment for sustainable learning in individuals with Down syndrome	Barcenilla, C. A.; Pavía, S.; Manzanares, M. C. S.; Romero, L. A. C.; González, S. G. (2024)	Web of Science
	Saberes contemporâneos na formação inicial de professores para atuar em uma perspectiva de Educação Inclusiva (Contemporary knowledge in the initial training of teachers to work from an inclusive education perspective)	Queiroz, F. M. M. G.; Barbosa, R. S. (2024)	Web of Science
	Assistive technologies in physics teaching to visually impaired students: a case study based on audio description	Santos, P. V.; Brandão, G. C. A. (2020)	SciELO
Dissertation	Tecnologia assistiva no ensino de Matemática para um aluno cego do Ensino Fundamental: desafios e possibilidades (Assistive technology in teaching	Salvino, L. G. M. (2017)	BDTD

TYPE	TITLE	AUTHOR/YEAR	DATABASE
	mathematics to a blind elementary school student: challenges and possibilities)		
	Gamificação como prática pedagógica docente no processo ensino e aprendizagem na temática da inclusão social (Gamification as a teaching practice in the teaching and learning process on the theme of social inclusion)	Garcia, A. (2015)	Google Scholar
	Criação participativa de jogos analógicos na abordagem do *design* universal para aprendizagem (Participatory creation of analog games using a universal design approach to learning)	Pereira, P. R. (2023)	CAPES
	Práticas pedagógicas e processos de inclusão digital na rede estadual de ensino do município de Anita Garibaldi-SC (Teaching practices and digital inclusion processes in the state education network of the municipality of Anita Garibaldi, Santa Catarina)	Siqueira, M. S. (2022)	CAPES
	Sequência didática pautada no desenho universal para a aprendizagem na área de Linguagens e suas Tecnologias (Teaching sequence based on universal design for learning in the area of Languages and their Technologies)	Baldan, R. K. (2023)	CAPES
	A utilização da Tecnologia Assistiva no ensino de Matemática para alunos com deficiência intelectual (The use of Assistive Technology in teaching mathematics to students with intellectual disabilities)	Nicácio, M. D. M. (2019)	CAPES
	Processo formativo docente para aprendizagem de conceitos estatísticos de estudantes surdos a	Cabral, A. C. A. P. (2022)	CAPES

TYPE	TITLE	AUTHOR/YEAR	DATABASE
	partir de uma perspectiva inclusiva (Teacher training process for teaching statistical concepts to deaf students from an inclusive perspective)		

Source: Own elaboration (2025).

The methodology adopted in this mapping is structured in two distinct stages. The first stage refers to a qualitative literature review, guided by the procedures proposed by Kitchenham and Charters (2007). According to the authors, the systematic review should be conducted in an organized and rigorous manner, identifying thematic focuses, allowing for a critical analysis of the existing literature in both an inductive and, in certain cases, deductive manner.

In the first stage, the analysis focused on the main results obtained in the academic works examined, with the aim of highlighting their most significant contributions to the field of study. At this stage, we sought to identify patterns, divergences, or convergences between the findings of the different studies, in addition to synthesizing the conclusions and recommendations presented by the authors.

The second stage of the analysis consisted of data processing, conducted based on the content analysis technique, as outlined by Bardin (2020). During this stage, the information extracted from the studies was carefully deconstructed and reorganized according to previously defined criteria, in order to ensure methodological consistency and alignment with the research objectives.

CHARACTERIZATION OF THE PUBLICATIONS INCLUDED IN THE REVIEW

From the analysis of the selected studies, three main categories emerged, designed to structure the investigation and group the contributions based on their thematic approaches. This categorization process was essential to assign meaning to the data, favoring critical interpretation and organization of the evidence in a manner consistent with the study objectives.

The categories, presented in Table 4, provided support for a more in-depth and systematic reading of the findings, enabling the identification of recurring patterns, conceptual convergences, and aspects relevant to understanding the phenomenon under investigation.

Table 4

Analytical categories and respective descriptions

CATEGORY	DESCRIPTION
(A) Universal Design for Learning (UDL) and Educational Equity	This category brings together studies that analyze the principles of UDL as a basis for the development of accessible teaching practices that are responsive to diversity. The research highlights UDL as an approach that promotes educational equity by providing, from the planning stage, multiple forms of engagement, representation, and expression, expanding the possibilities for participation and learning for all students.
(B) Teacher Training Development	Refers to continuous and intentional training processes aimed at improving teaching practices through actions such as courses, spaces for critical reflection on practice, sharing experiences, and analyzing evidence. The focus is on teaching qualifications and their effects on student learning, seeking to promote more effective interventions that are responsive to educational demands.
(C) Digital Technologies, Assistive Technologies, and Inclusion	This group brings together research that explores the impact of DATs on the teaching and learning process of students with disabilities, highlighting their potential as pedagogical mediation devices aimed at promoting educational inclusion. These studies analyze how such technologies contribute to expanding access to the curriculum, encouraging active participation, and responding to the specific needs of these students in the school context.

Source: Own elaboration (2025).

Although these categories were established as guiding focuses for organizing the data, throughout the analysis it became evident that they are naturally intertwined. ADTs, for example, appear not only as support resources, but as fundamental elements in the construction of more inclusive pedagogical practices that are often based on the principles of UDL.

Similarly, the integration of technological resources and strategies based on UDL is intrinsically related to the adoption of active and innovative methodologies, in addition to requiring training processes that enable teachers to act sensitively and competently in the face of diversity in the school environment.

Thus, the separation of categories does not mean treating the themes as isolated compartments, but rather as different lenses that enable us to see, with greater clarity, the multiple dimensions of inclusive education mediated by technologies. At the same time, recognizing these interrelationships was essential

to construct a broader and more articulated analysis, respecting the complexity of the object of study.

Table 5 organizes the authors according to the main research categories identified throughout the study. Each author is allocated to the most relevant categories of their research, allowing for a structured view of the areas of investigation addressed. It should be noted that the same author may be included in more than one category, considering the thematic scope of their work.

Table 5

Distribution of publications according to analytical categories and authorship

CATEGORY	AUTHOR/YEAR
(A) Universal Design for Learning (UDL) and Educational Equity	Bucheli, M. G. V.; Mesa, M. L. C.; Galán, J. G.; Catalán, L. L. (2024)
	Queiroz, F. M. M. G.; Barbosa, R. S. (2024)
	Baldan, R. K. (2023)
(B) Teacher Training Development	Cabral, A. C. A. P. (2022)
	Nicácio, M. D. M. (2019)
	Queiroz, F. M. M. G.; Barbosa, R. S. (2024)
	Salvino, L. G. M. (2017)
(C) Digital Technologies, Assistive Technologies, and Inclusion	Barcenilla, C. A.; Pavía, S.; Manzanares, M. C. S.; Romero, L. A. C.; González, S. G. (2024)
	Bucheli, M. G. V.; Mesa, M. L. C.; Galán, J. G.; Catalán, L. L. (2024)
	Garcia, A. (2015)
	Nicácio, M. D. M. (2019)
	Pereira, P. R. (2023)
	Salvino, L. G. M. (2017)
	Santos, P. V.; Brandão, G. C. A. (2020)
	Siqueira, M. S. (2022)

Source: Own elaboration (2025).

ANALYSIS BY CATEGORIES

The categorization of findings emerged from content analysis, resulting in three main areas of discussion: (A) UDL and educational equity; (B) Teacher training and inclusive teaching practices; and (C) Assistive Digital Technologies in the teaching and learning process. Based on these categories, the selected studies were analyzed, allowing for the identification of contributions, recurrences, and gaps, organized further by thematic axis.

The analysis was structured to highlight both the specificities of each category and the relationships established between them, enabling a broader and more integrated understanding of the trends and gaps present in research on inclusion and innovative pedagogical practices.

Analysis of Category A Studies

The studies analyzed converge in highlighting UDL as a promising framework for inclusive education, albeit with different approaches. Bucheli et al. (2024) and Baldan (2023) share the perspective that UDL should be applied in an intentional and planned manner, avoiding superficial adoption. While Bucheli et al. (2024) investigate the integration between Digital Technologies (DT) and the principles of UDL in higher education, Baldan (2023) focuses on the development of structured pedagogical proposals aimed at basic education, highlighting the versatility of the model at different educational levels. Both works reinforce that the mere incorporation of resources or strategies, without consistent pedagogical planning, does not guarantee the effectiveness of UDL, pointing to the need for teacher training and contextualized pedagogical adaptation.

However, there is an implicit divergence in the emphasis given to technological resources. Bucheli et al. (2024) highlight DT as facilitators of UDL, especially with regard to multimedia representation and engagement through gamification. Baldan (2023), on the other hand, prioritizes structured teaching sequences, without necessarily linking UDL to DT, suggesting that accessibility can be achieved through adapted traditional pedagogical strategies. This difference may reflect the specificities of higher education and basic education contexts, but it also indicates an implicit debate about the need to associate UDL with innovative technologies or the possibility of its implementation with resources already available in schools.

Queiroz and Barbosa (2024) expand the debate by addressing initial teacher training, highlighting UDL as a fundamental component in the construction of inclusive pedagogical practices. This study is in line with the others, as it reinforces that the implementation of UDL requires adequate professional preparation, but differs in that it does not delve into specific application strategies, focusing more on future teachers' perception of its importance. This perspective complements the work of Bucheli et al. (2024) and Baldan (2023) by suggesting that teacher training is a prerequisite for the effectiveness of UDL, whether in the use of technologies or in the development of teaching sequences.

A common gap identified in the three studies is the lack of research on the long-term impacts of UDL implementation. Bucheli et al. (2024) indicate the need for further research in this area, while Baldan (2023) and Queiroz and Barbosa (2024) do not directly address the continuous evaluation of results. In addition, all three studies are restricted to specific contexts (higher education, basic education, and teacher training), leaving open the adaptation of UDL to non-formal education settings or broader public policies.

Finally, the studies reinforce that UDL is a viable approach to inclusion; however, its effectiveness depends on contextualized implementation, teacher training, and continuous assessment. While Bucheli et al. (2024) highlight the

potential of technologies, Baldan (2023) demonstrates that well-structured pedagogical strategies are also effective, and Queiroz and Barbosa (2024) emphasize the importance of initial training. Together, these studies show that there is no single path for applying UDL, but rather multiple possibilities that must be adapted to the needs of students and educational realities.

Analysis of Category B Studies

In the field of teacher training, the studies analyzed converge in highlighting the importance of training courses that qualify teachers to respond to the multiple demands of diversity in the school context. Cabral (2022) and Nicácio (2019) highlight the importance of collaborative training between teachers and specialists, emphasizing that continuing education is essential to overcome limitations in inclusive teaching practices. Both studies point to gaps in teacher preparation, whether in teaching statistics to deaf students or working with students with intellectual disabilities.

Queiroz and Barbosa (2024) complement this perspective by advocating for the incorporation of specific knowledge about inclusive education in initial teacher training, such as individualized plans and curricular adaptations. This approach is corroborated by Salvino (2017), who warns of the risks of pseudo-inclusion practices and advocates for teacher training in the use of accessible pedagogical resources. Salvino (2017) demonstrates how a lack of adequate preparation can result in situations of exclusion in the school environment.

A relevant convergence among the authors refers to the need for transformations in both methodological approaches and the structures that support teacher training. Nicácio (2019) and Salvino (2017) emphasize that effective inclusion requires individual training, as well as adequate material conditions and institutional support. In contrast, Cabral (2022) emphasizes the potential of collaborative work between different educational actors as a strategy to overcome contextual limitations.

There are significant gaps in the studies analyzed, especially with regard to the cross-cutting incorporation of inclusive practices in different curricular components. There is also a lack of research addressing training strategies for complex multicultural contexts, as well as little emphasis on the role of families and communities in the teacher training process. Another limitation pointed out refers to the need for greater articulation between theoretical knowledge and the practical demands of everyday school life.

The studies converge in pointing out the importance of continuous, collaborative training processes focused on accessible pedagogical practices. However, significant challenges remain regarding the effective incorporation of these principles into training curricula and the need for more comprehensive approaches that consider diversity in its complexity. The studies analyzed suggest the urgent need for training models that provide teachers with concrete tools to work in diverse classrooms, overcoming the limitations of traditional approaches.

Analysis of Category C Studies

When analyzing the relationships between authors in the field of ADTs and Inclusion, significant convergences can be observed with regard to the potential of technological tools to promote accessibility and active participation of people with disabilities. Barcenilla et al. (2024) demonstrate that well-structured educational platforms can be effective in teaching sustainability to students with Down syndrome, with high acceptance rates among educators. This approach is expanded upon by Bucheli et al. (2024), who show that Digital Technologies enable various forms of knowledge representation, favoring adaptation to different learning styles in higher education.

In terms of specific resources, Garcia (2015) and Pereira (2023) share the perspective that digital and analog games have pedagogical value as inclusive resources. While Garcia (2015) developed a game to raise awareness about disabilities, Pereira (2023) focused on the collaborative creation of games as a strategy to engage students with and without disabilities. Both studies highlight the need for adjustments to pedagogical resources to ensure their effectiveness among different audiences.

Nicácio (2019) and Salvino (2017) explore the use of assistive technologies in mathematics teaching in a complementary manner, each highlighting specific aspects of this pedagogical application. Nicácio (2019) highlights the role of manipulative and digital games in the development of cognitive skills in students with intellectual disabilities, while Salvino (2017) investigates the combined use of soroban, Braille, and digital technologies for blind students. Both identify similar challenges in the practical implementation of these resources, particularly with regard to the adaptation of materials and the need for adequate infrastructure.

Santos and Brandão (2020) contribute with a specific analysis on the use of audio description in teaching physics to students with visual impairments, showing that, when combined with tactile resources, this technology can significantly reduce barriers to the learning process. Their findings are in line with those of Salvino (2017) in recognizing that isolated technological solutions are insufficient to ensure full inclusion.

An implicit divergence appears between studies that emphasize the transformative potential of digital technologies, such as Bucheli et al. (2024), and those that warn of the limits of their implementation. Siqueira (2022) demonstrates that, despite rapid advances in the use of DT during the pandemic, its incorporation into pedagogical practices remains uneven and dependent on structural factors. This critical perspective complements the studies by Nicácio (2019) and Salvino (2017), which identify concrete challenges in the daily application of assistive technologies.

The main gaps pointed out by the authors include the need to develop more adaptable resources (Garcia, 2015), the lack of adequate infrastructure (Siqueira, 2022), and the importance of multimodal approaches that combine different technologies (Santos & Brandão, 2020). In addition, several studies suggest the need for research to assess the long-term impacts of these technological interventions in diverse educational contexts.

CONNECTIONS BETWEEN CATEGORIES

Table 4 shows only the connections between categories, highlighting the relationships established by authors whose research dialogues with more than one thematic area.

Analysis of Connections between Categories A + B

The study by Queiroz and Barbosa (2024) points to the relationship between teacher training and the implementation of UDL as a strategy for educational equity. The research demonstrates that the inclusion of content on UDL in initial teacher training enables future teachers to recognize the importance of inclusive pedagogical practices, such as curricular adaptations and the integration of assistive technologies.

The results show that teacher training is crucial for consolidating knowledge that supports the promotion of educational equity based on the principles of UDL. However, they also reveal the need for more effective articulation between theory and practice, indicating that teacher training should incorporate concrete experiences that enable educators to apply this knowledge in real school contexts marked by diversity.

Analysis of the Connections between Categories A + C

The research by Bucheli et al. (2024) establishes a direct relationship between DT (category C) and the implementation of UDL principles (category A), demonstrating how these resources can operationalize educational equity in higher education. The authors show that students perceive DT as facilitators of the three principles of UDL: engagement (through gamification and audiovisual materials), representation (through multimedia resources), and action/expression (with interactive resources that offer multiple ways of demonstrating knowledge).

This interaction between technology and UDL principles reinforces that DT, when aligned with intentional pedagogical planning (Bucheli et al., 2024), can materialize the assumptions of educational equity by addressing student diversity. However, the authors caution that the simple insertion of technologies into the school environment does not, in itself, ensure the effectiveness of inclusion, highlighting the importance of adequate structural conditions and training processes that qualify teachers for their pedagogical use.

The study by Baldan (2023) complements this discussion, as it demonstrates how a teaching sequence based on UDL can incorporate DT to promote inclusive practices. The research reveals that the combination of UDL principles and technologically mediated strategies allows for the creation of accessible approaches that respect different learning styles. Participating teachers recognized that the proposed teaching sequence not only operationalizes UDL principles in practice but also encourages reflection on more inclusive pedagogical planning. This finding shows that the integration of UDL and technologies, when properly structured, can impact teachers' conceptions of educational equity. The versatility

of the proposal—adaptable to different areas of knowledge—reinforces the potential of DT as facilitators for implementing UDL principles in multiple contexts.

Together, these studies highlight a relationship of mutual dependence between the categories analyzed: DT (category C) emerge as privileged means for implementing the principles of UDL (category A), while UDL provides the theoretical and methodological basis for technologies to effectively fulfill their inclusive role. As demonstrated by Bucheli et al. (2024), DT enhance the three principles of UDL, but require intentional pedagogical mediation. Baldan (2023) shows that the effectiveness of this combination depends on well-structured teaching materials and teacher training. These studies highlight that the synergy between UDL and DT must always be guided by a clear purpose of educational equity, considering both the potential of digital tools and the contexts in which they are implemented.

Analysis of the Connections between Categories B + C

The studies analyzed reveal how teacher training and ADTs are linked in inclusive educational practice, highlighting points of convergence between these two dimensions. Nicácio (2019) and Salvino (2017) converge in identifying that the effectiveness of technologies in promoting inclusion is directly linked to the preparation of educators, creating a relationship of interdependence between the two dimensions.

The first point of convergence between the authors arises from the observation that DT only reach their inclusive potential when mediated by adequately trained teachers. Nicácio (2019) shows that digital and manipulative games improve learning in mathematics, but only become effective when Specialized Educational Services teachers receive specific training in their use—a gap that the study seeks to address with the proposal for a training course. In the same vein, Salvino (2017) demonstrates that even established technologies, such as the soroban and Braille, depend on qualified teacher mediation, exposing how pseudo-inclusion arises precisely at times when there is a lack of technical knowledge and pedagogical engagement on the part of educators.

Another key point of convergence is the criticism of teacher training that is disconnected from the demands of inclusion. Both studies reveal a vicious circle: the lack of training leads to underuse of technologies, which in turn limits inclusive possibilities. Nicácio (2019) identifies this dynamic in the concrete obstacles faced by teachers (lack of time, insufficient workload), while Salvino (2017) explains it in the exclusionary practices resulting from teacher unpreparedness. Both works argue that technology does not operate in a vacuum, depending on a training context that prepares teachers for its critical and creative use.

The third point of intersection between the authors arises in the conception of teacher training as a continuous and contextualized process. The authors do not advocate generic training, but rather training linked to the specificities of the technologies and target audiences. Nicácio (2019) proposes a course focused on mathematical games for intellectual disabilities, while Salvino (2017) emphasizes the need to master specific technologies for the blind. This harmony reveals that

training development must be as diverse as the technologies and educational needs themselves, establishing a constant dialogue between the two categories.

FINAL CONSIDERATIONS

Considering the guidelines of the BNCC (2018) and the challenges imposed by diversity in the school context, it is essential to redefine the teaching of science and mathematics through approaches that promote inclusion and ensure educational equity. The integration of Assistive Digital Technologies (ADTs) and the principles of Universal Design for Learning (UDL) is a powerful strategy for ensuring access, active participation, and success for all students, respecting their different ways of learning and expressing themselves.

The systematic review allowed us to build a solid understanding of the impact of ADTs on science and mathematics education from a UDL perspective. The careful selection of 11 studies and content analysis resulted in three main thematic areas: (A) UDL and educational equity; (B) Teacher training and inclusive teaching practices; and (C) Assistive Digital Technologies in the teaching and learning process. This categorization facilitated the identification of patterns, contributions, and gaps in the literature, contributing to a critical and articulated view of the field under investigation.

In category A, it was observed that UDL represents a promising path to inclusion, provided it is based on pedagogical planning, teacher training, and contextual adaptations. Studies show that its effective application requires more than the simple use of technologies: it requires intentionality, curricular flexibility, and professional preparation.

In category B, teacher training emerged as a central factor for the consolidation of inclusive practices, highlighting the need for continuous, collaborative training processes aligned with the reality of schools. Gaps were also identified in family involvement and in the mainstreaming of inclusive practices in different areas of knowledge, pointing to the urgency of intersectoral actions in the educational process.

Category C highlighted the role of ADTs as tools capable of increasing accessibility and promoting the participation of students with disabilities. Resources, exemplified by digital games and adapted materials, proved to be effective, although structural challenges, such as lack of infrastructure and the need for specific technical training, still limit their full use. The scarcity of studies on the long-term impacts of these interventions reinforces the importance of future research in this field.

The integrated analysis of the axes revealed the interdependence between teacher training, UDL, and the use of ADTs, pointing out that these elements should not be considered in isolation. The articulation between theory and practice, combined with investment in infrastructure and continuing education, is essential to transform technology into an ally of inclusion, avoiding pseudo-inclusion and promoting truly accessible and equitable education.

Considering the guidelines of the BNCC (2018), the LBI (2015), and Decree No. 10,502/2020, it is essential to reframe the teaching of science and mathematics

through inclusive approaches. The review identified three central axes (UDL and equity, teacher training, and ADTs); however, it has limitations, such as the small number of empirical studies and the absence of longitudinal analyses on the impacts of UDL and ADTs. The results reinforce the need to continuously relate the principles of UDL (engagement, representation, and action/expression) to public policies and school practices. Future research may deepen the understanding of the effectiveness of these technologies in different educational contexts, as well as their articulation with initial and continuing teacher training.

REFERENCES

Baldan, R. K. (2023). *Sequência didática pautada no desenho universal para a aprendizagem na área de linguagens e suas tecnologias.* (Dissertação de Mestrado), Universidade Estadual Paulista (Unesp), São Paulo. http://hdl.handle.net/11449/244356

Barcenilla, C. A., Pavía, S., Manzanares, M. C. S., Romero, L. A. C., & González, S. G. (2024). Developing an adaptive virtual learning environment for sustainable learning in individuals with Down syndrome. *International Journal of Inclusive Learning and Teaching*, 41(3), 318-337. https://doi.org/10.1108/IJILT-10-2023-0200

Bardin, L. (2020). *Análise de conteúdo*. Edições 70.

Base Nacional Comum Curricular (BNCC). (2018). Brasília, DF. https://basenacionalcomum.mec.gov.br/

Booth, A., Sutton, A., & Papaioannou, D. (2019). *Systematic approaches to a successful literature review* (2nd ed.). SAGE Publications Ltd.

Bucheli, M. G. V., Mesa, M. L. C., Galán, J. G., & Catalán, L. L. (2024). Digital technologies as enablers of universal design for learning: higher education students' perceptions in the context of SDG4. *Discover Sustainability*, 5(473).

Cabral, A. C. A. P. (2022). *Processo formativo docente para aprendizagem de conceitos estatísticos de estudantes surdos a partir de uma perspectiva inclusiva*. (Dissertação de Mestrado), Universidade Federal do Rio Grande do Norte, Rio Grande do Norte. https://sucupira-legado.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=13123586

CAST. (2018). *Universal Design for Learning Guidelines version 2.2.* CAST. https://udlguidelines.cast.org/

Costa, L. R., & Nascimento, A. P. (2022). O Desenho Universal para Aprendizagem como estratégia inclusiva no ensino de Ciências. *Revista Ibero-Americana de Estudos em Educação*, 17(3), 1882-1899.

Cunha, L. L. da, Leite, R. L., Santos, F. D. G. dos, & Pinto, M. F. (2023). Como os medicamentos e a automedicação são abordados nos livros didáticos de biologia? *ACTIO: Docência em Ciências*, 8(2), 1-24. http://dx.doi.org/10.3895/actio.v8n2.15333

D'Ambrósio, U. (2005). *Educação matemática: da teoria à prática.* (6ª ed.). Papirus.

Decreto nº 10.502, de 30 de setembro de 2020. (2020). Institui a Política Nacional de Educação Especial: Equitativa, Inclusiva e com Aprendizado ao Longo da *Vida.* Diário Oficial da União, Brasília, DF. http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/decreto/D10502.htm

Garcia, A. (2015). *Gamificação como prática pedagógica docente no processo ensino e aprendizagem na temática da inclusão social*. (Mestrado em Ensino de Ciências Humanas, Sociais e da Natureza), Universidade Tecnológica Federal do Paraná, Londrina. http://repositorio.utfpr.edu.br/jspui/handle/1/1666

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. *Technical Report*, Version 2.3. EBSE.

Lei nº 13.146, de 6 de julho de 2015. (2015). Institui a Lei Brasileira de Inclusão da Pessoa com Deficiência (Estatuto da Pessoa com Deficiência). Diário Oficial da União, Brasília, DF. http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2015/lei/l13146.htm

Lima, P. R., Oliveira, M. S., Santos, A. L., & Souza, T. F. (2023). Princípios do Desenho Universal para Aprendizagem aplicados ao ensino de Matemática: perspectivas inclusivas e digitais. *Revista Educação Especial*, 36, e45.

Lorenzetti, L., & Delizoicov, D. (2001). O ensino de Ciências e a questão ambiental: fundamentos e possibilidades pedagógicas. *Ciência & Educação*, 7(2), 165-178.

Nicácio, M. D. M. (2019). *A utilização da tecnologia assistiva no ensino de Matemática para alunos com deficiência intelectual*. (Dissertação de Mestrado), Universidade Federal do Acre, Rio Branco. https://sucupira-legado.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=8796617

Oliveira, T. R., & Rocha, A. R. (2021). Tecnologias assistivas digitais no ensino de Matemática: contribuições para a inclusão. *Revista Brasileira de Educação Especial*, 27(2), 241-258.

Pereira, P. R. (2023). *Criação participativa de jogos analógicos na abordagem do design universal para aprendizagem*. (Dissertação de Mestrado), Universidade do Vale do Itajaí, Itajaí. https://sucupira-legado.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=13837529

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: a practical guide*. Blackwell Publishing.

Plano Nacional de Educação: PNE 2014-2024: Linha de base. (2015). Brasília, DF. https://www.gov.br/inep/pt-br/centrais-de-conteudo/acervo-linha-editorial/publicacoes-institucionais/plano-nacional-de-educacao/plano-nacional-de-educacao-pne-2014-2024-linha-de-base

Queiroz, F. M. M. G., & Barbosa, R. S. (2024). Saberes contemporâneos na formação inicial de professores para atuar em uma perspectiva de Educação Inclusiva. *Revista Brasileira de Educação do Campo*, 9, e19385. https://www-webofscience-com.ez181.periodicos.capes.gov.br/wos/woscc/full-record/WOS:001378407400001

Ramalho, M. R., & Lima, F. A. (2023). Tecnologias Digitais Assistivas e inclusão escolar: práticas e desafios. *Revista Educação & Tecnologias*, 18(3), 55-72.

Ramalho, P. C., & Luna, A. S. A. (2023). Tecnologias assistivas na educação inclusiva: promovendo a inclusão de alunos com deficiência. *Ciências da Saúde*, 27(126).

Resolução CNE/CP nº 2, de 20 de dezembro de 2019. (2019). Define as Diretrizes Curriculares Nacionais para a Formação Inicial de Professores para a Educação Básica e institui a Base Nacional Comum para a Formação Inicial de Professores da Educação Básica (BNC-Formação). Brasília, DF. https://tinyurl.com/52bfau6d

Salvino, L. G. M. (2017). *Tecnologia assistiva no ensino de Matemática para um aluno cego do Ensino* Fundamental: desafios e possibilidades. (Dissertação de Mestrado), Universidade Estadual da Paraíba, Campina Grande. https://tede.bc.uepb.edu.br/jspui/handle/tede/2906

Santos, P. V., & Brandão, G. C. A. (2020). Assistive Technologies in Physics Teaching to Visually Impaired Students: a case study based on audio description. *Ciência & Educação (Bauru)*, 26. https://doi.org/10.1590/1516-731320200046

Sebastián-Heredero, E., Prais, L., & Vitaliano, C. (2022). *Desenho Universal para a Aprendizagem (DUA*): uma abordagem curricular inclusiva. Editora da Castro.

Silva, J. F., et al. (2022). Inclusão e acessibilidade digital: o uso de tecnologias assistivas na educação básica. *Revista Educação e Cultura Contemporânea*, 19(51), 233-254.

Siqueira, M. S. (2022). Práticas pedagógicas e processos de inclusão digital na rede estadual de ensino do município de Anita Garibaldi-SC. *ACTIO: Docência em Ciências,* 7(3), 1-20. https://doi.org/10.3895/actio.v7n3.14222

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207-222. https://doi.org/10.1111/1467-8551.00375

Zabala, A. (1998). *A prática educativa: como ensinar*. Artmed.

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