

Universal design for learning in initial biology teacher education: reflections on an inclusive teaching practice

ABSTRACT

In response to the diversity found in today's classrooms, Universal Design for Learning (UDL) has emerged as an important curricular approach to removing barriers to learning and promoting equitable opportunities. Thus, this study was guided by the following question: How does the experience of planning and teaching a lesson grounded in UDL principles contribute to preparing prospective Biology teachers to work in diverse educational contexts? The main objective was to analyze a teacher education experience in an undergraduate Biological Sciences program focused on developing inclusive pedagogical practices based on UDL. The study adopted a qualitative case study approach. Data were collected through systematic observation, reflective journals, and semi-structured interviews. Three prospective teachers enrolled in the Biological Sciences teacher education program participated in the study. The data were analyzed from a critical perspective using Discursive Textual Analysis (DTA), which led to the development of three final categories: (i) Planning inclusive practices in science teaching; (ii) The inclusive learning environment; and (iii) The importance of inclusive practice in teacher education. The findings show that incorporating UDL into initial teacher education provided opportunities to engage in inclusive practices, contributing to initial efforts to overcome ableist barriers and build pedagogical confidence. Collaborative work and curriculum flexibility transformed classroom dynamics and enabled all students to participate. Further theoretical and practical engagement with this framework may contribute significantly to the development of inclusive curricula and pedagogical practices.

KEYWORDS: inclusive education; UDL; diversity; teacher education.

Rafaela Rocha-Oliveira

rroliveira.ppgedm@uesc.br

orcid.org/0000-0001-7933-2056

Universidade Estadual de Santa Cruz
(UESC), Ilhéus, Bahia, Brazil

Maria José Souza Pinho

mjpinho@uneb.br

orcid.org/0000-0002-5129-7479

Universidade do Estado da Bahia
(UNEB), Senhor do Bonfim, Bahia,
Brazil

Viviane Borges Dias

vbdias@uesc.br

orcid.org/0000-0003-4528-5110

Universidade Estadual de Santa Cruz
(UESC), Ilhéus, Bahia, Brazil

O desenho universal para a aprendizagem na formação inicial de professores de biologia: reflexões a partir de uma prática inclusiva

RESUMO

Diante da diversidade presente nas salas de aula, o Desenho Universal para a Aprendizagem (DUA) tem se destacado como uma abordagem curricular fundamental para eliminar barreiras à aprendizagem e promover oportunidades equitativas. A questão que orientou este estudo foi, portanto: Como a vivência de planejar e ministrar uma aula pautada pelos princípios do DUA contribui para a formação inicial de professores de Biologia para atuarem em contextos de diversidade? O objetivo principal foi analisar uma experiência formativa no curso de Ciências Biológicas, centrada no desenvolvimento de práticas pedagógicas inclusivas com base no DUA. A pesquisa adotou uma abordagem qualitativa, do tipo estudo de caso. Os instrumentos para obtenção de informações foram a observação sistemática, os diários de bordo e as entrevistas semiestruturadas. Participaram do estudo três licenciandos do curso de licenciatura em Ciências Biológicas. A análise foi baseada na abordagem crítica, por meio da Análise Textual Discursiva (ATD), o que permitiu a elaboração de três categorias finais: i) O planejamento da prática inclusiva no ensino de Ciências; ii) O ambiente de aprendizagem inclusivo; iii) A importância da prática inclusiva na formação de professores. Os resultados revelam que a abordagem do DUA na formação inicial propiciou a vivência de práticas inclusivas, contribuindo para a superação inicial de barreiras capacitistas e de inseguranças pedagógicas. A coletividade e a flexibilização curricular transformaram a dinâmica da aula, possibilitando a participação de todos os estudantes. O aprofundamento teórico e prático desse referencial pode contribuir significativamente para a estruturação de currículos e de práticas pedagógicas inclusivas.

PALAVRAS-CHAVE: educação inclusiva; DUA; diversidade; formação docente.

INTRODUCTION

Public policies aimed at including students with disabilities have contributed to reshaping the profile of Brazilian basic education. According to the 2024 School Census, published by the Anísio Teixeira National Institute for Educational Studies and Research (INEP), approximately 4.46% of students in Brazilian basic education were classified as students with disabilities, pervasive developmental disorders, and/or giftedness (INEP, 2025). Although difference in school settings is commonly associated with students with disabilities, it is an intrinsic feature of schools, reflected in the plurality of bodies, cultures, and types of intelligence that traditional teaching often overlooks (Abramowicz et al., 2011). However, the growing visibility of disability-related difference in mainstream schools has prompted a necessary reconsideration of pedagogical practices to ensure inclusive learning environments.

While most studies on school inclusion tend to address disabilities and disorders individually, the everyday reality of teachers in mainstream classrooms requires them to include students with different conditions simultaneously, whether related to disabilities, disorders, or other individual characteristics. This scenario is characteristic of inclusive education, which “is not intended for a specific group, but for the entire student body” (Crochick et al., 2020, p. 3). Information about the specific characteristics of each type of disability can support teachers; however, it may at times prove insufficient for conceptualizing inclusive education (Valle & Connor, 2014). In seeking to move beyond the medical model, we agree with Crochick et al. (2020), who argue that education “must move beyond its adaptive emphasis on objective social conditions and embrace democratic and humanizing education, involving all students, regardless of gender, sex, social, economic, or ethnic background, or whether or not they have a disability” (p. 8).

One of the barriers faced by students with disabilities in accessing the learning process is prejudice in the school environment. Perhaps one of its most serious manifestations occurs through the provision of different content. We agree with Crochick (2013), who states:

Recognizing the difficulties some students—not only those considered to be in situations of inclusion—have in keeping up with the content being taught is important and should guide teachers toward other teaching methods or toward adapting/adjusting the content being taught. However, providing different content may become a mechanism of segregation in relation to other students, as though those considered to be in situations of inclusion were not part of the group. (pp. 19–20)

When different content is provided, students with disabilities are not only excluded from the collective learning environment but are also denied the right to access “curricula and their minimum content requirements, so as to ensure a common basic education” (Law No. 9,394, 1996, art. 9). In this context, Universal Design for Learning (UDL) provides curricular principles for organizing pedagogical practice in ways that address student diversity, remove barriers, and support the learning of all students (Sebastian-Heredero et al., 2022).

Inspired by the concept of universal accessibility to spaces, products, and services, UDL proposes intentionally flexible and accessible planning, based on the premise that teaching should be designed from the outset to accommodate

diversity rather than subsequently adapted to address different needs (Meyer et al., 2014). In this context, Sebastian-Heredero et al. (2022) distinguish between curricular adaptation and curricular differentiation. The former involves individualized adaptations that often impose lower expectations. This occurs, for example, when a teacher assigns a different activity to a student with a disability during class. Curricular differentiation, in turn, is based on the idea that planning should provide multiple ways of teaching and a variety of resources, enabling all students to participate in the learning process (Sebastian-Heredero et al., 2022).

In the context of initial teacher education in Science and Biology, studies indicate that the preparation of these professionals to work in inclusive settings is still frequently insufficient (Dias & Silva, 2020; Prado & Mol, 2024; Silva & Dias, 2025). Many teachers complete their teacher education programs without having had opportunities, either in theory or in practice, to design and implement strategies for inclusive teaching.

Based on this premise and drawing on an experience in the course 'Pedagogical Practice in Biology', offered as part of the Biological Sciences teacher education program at the State University of Bahia (UNEB), we sought to answer the following research question: How does the experience of planning and teaching a lesson grounded in UDL principles contribute to initial teacher education for Biology teachers preparing to work in diverse educational contexts?

Accordingly, our aim was to analyze a teacher education experience in the Biological Sciences program focused on the development of inclusive pedagogical practices based on UDL. More specifically, we sought to identify the main challenges perceived by prospective teachers when planning UDL-based Science lessons and to understand how this practical experience influenced their perceptions of school inclusion and their perceived ability to teach in diverse educational contexts.

TEACHER EDUCATION FOR WORKING IN INCLUSIVE SCHOOL SETTINGS

This section highlights two central and pressing issues in teacher education for inclusive education. First, we believe that teacher education curricula should incorporate a theoretical foundation that understands "differences as producing further differences, which cannot be reconciled, since they are not contradictions" (Candau, 2011, p. 91). Second, the debate on inclusive education needs to extend beyond students with disabilities by recognizing that mechanisms of exclusion in schools affect all those who deviate from socially established norms (Crochick, 2013).

From the perspectives of Candau (2011) and Abramowicz et al. (2011), diversity—a recurring concept in policies and official discourse—tends to involve recognizing and valuing cultural identities as a resource to be incorporated into the school environment. Within this logic, inclusive education is understood as the acceptance and accommodation of diverse groups within a preexisting structure, promoting coexistence through a discourse of tolerance (Abramowicz et al., 2011; Candau, 2011).

By contrast, the political and critical dimension of difference challenges the power relations and norms that determine who is considered "normal" and who is

marginalized (Candau, 2011). Inclusive education therefore requires dismantling the barriers and prejudices that lead to exclusion (Crochick, 2013), seeking not only to include those perceived as different but also to transform schools and curricula so that they do not reinforce hierarchies and instead become spaces of contestation and justice.

Thus, a superficial understanding of diversity may lead to a form of pseudo-inclusion that merely manages plurality, whereas difference points toward a transformative form of inclusion that confronts the structural causes of inequality (Abramowicz et al., 2011). Inclusive education should therefore be understood in its radical dimension, challenging the structures that marginalize difference in its multiple expressions.

In this context, “strengthening initial and continuing teacher education becomes imperative, fostering the development of a curriculum that responds to the demands of inclusive teaching” (Gomes et al., 2025, p. 20). The National Curriculum Guidelines for Initial Higher Education of Basic Education Teaching Professionals (National Education Council/Full Council [CNE/CP] Resolution No. 4 of May 29, 2024) represent an important step forward by stating that graduates of teacher education programs should be able to develop differentiated teaching strategies and activities in order to ensure the inclusion of students with disabilities in the learning process. Despite this legal progress, the major challenge lies in translating these guidelines into the curricular structure and practices of teacher education programs.

Evidence of this gap between policy and practice is abundant in the literature. Studies indicate a widespread sense of unpreparedness to address inclusion in schools (Gomes et al., 2025; Prado & Mol, 2024). Research also indicates that the topic receives limited attention in initial teacher education, often being confined to an elective course and/or a single faculty member (Dias & Silva, 2020; Prado & Mol, 2024). Although Dias and Silva (2020) emphasize that a course devoted to inclusive education constitutes an important space of resistance, one course alone is insufficient to address the complexity of the debate.

A study conducted by Vilela-Ribeiro and Benite (2013) with Science teacher educators found that, although there was receptiveness to inclusive approaches, clear gaps remained in the preparation of faculty to work with diversity and to prepare future teachers to do the same. Accordingly, the authors argue that “supporting the continuing education of university faculty is a fundamental initiative for improving the preparation of Basic Education Science teachers with regard to practices for diversity” (Vilela-Ribeiro & Benite, 2013, p. 792). To be effective, such education must extend beyond theoretical discussions and incorporate concrete pedagogical experiences that challenge prejudices surrounding inclusive practices (Gomes et al., 2025; Prais & Vitaliano, 2022).

Against this backdrop, it is important to rethink initial teacher education and invest in the continuing education of Science and Biology teachers. Several authors emphasize the urgent need for teacher education programs to foster the development of specific competencies for reflection and inclusive pedagogical practice (Benite et al., 2015; Prado & Mol, 2024; Silva & Dias, 2025).

UNIVERSAL DESIGN FOR LEARNING: PLANNING ACTIVITIES FOR ALL STUDENTS

The inherent complexity of school environments makes it clear that there is no single way of learning or single type of intelligence that applies to all students (Valle & Connor, 2014). In response to this diversity and in the pursuit of inclusive pedagogical practices, researchers at the Center for Applied Special Technology (CAST) developed the concept of Universal Design for Learning (UDL) (Sebastián-Heredero et al., 2022).

Originating in architecture, where the aim was to create environments accessible to everyone, the concept was later applied to education. In pedagogical practice, UDL comprises a set of principles designed to anticipate and reduce barriers to teaching and learning (CAST, 2024). Applied research has demonstrated progress in both behavior modification and the effective inclusion of students with disabilities in mainstream schools (Oliveira et al., 2019).

In this study, we adopt an understanding of UDL as a theoretical foundation for structuring the curriculum, which is translated into planning and teaching practices committed to inclusion (Sebastián-Heredero et al., 2022). This approach proposes a flexible and accessible instructional design aimed at removing barriers and expanding learning opportunities equitably (Meyer et al., 2014). From this perspective, differences among students guide pedagogical practices and the organization of goals, materials, methods, and assessment, with a view to promoting the learning and engagement of all students (Sebastián-Heredero et al., 2022). We concur with Silva and Massaro's (2022) assertion that UDL has the potential to enable "the participation of all students without there being a single way of assigning meaning to learning" (p. 4).

UDL is structured around three guiding principles: (I) multiple means of engagement, which address the affective dimension; (II) multiple means of representation, related to the presentation of information; and (III) multiple means of action and expression, which encompass the ways in which students demonstrate learning (CAST, 2024). This framework therefore envisions a curriculum that is open to differences and guided by students' individual characteristics (Sebastián-Heredero et al., 2022). However, developing a curriculum with this degree of flexibility requires teacher education, the acquisition of new knowledge, and practical experience, with UDL understood as a professional competency to be developed through the practical articulation of goals, student characteristics, pedagogical strategies, and the use of technology (Edyburn, 2010).

UDL-based curriculum planning is a pedagogical approach that seeks to eliminate barriers from the outset. To put this perspective into practice, the lesson-planning process proposed by Meo (2008) provides a practical framework that requires careful analysis of how each curricular component—goals, teaching strategies, materials, resources, and assessment—can be structured to promote inclusive education. The range of possibilities for teaching a given topic shows that difficulties generally lie not within the learner but in the methodological pathways made available to them (Prais & Vitaliano, 2022).

Within this process, the three neurodidactic principles of UDL provide the foundation for creating challenging learning environments for all students (Nunes

& Madureira, 2015). In practice, this involves, for example, defining broad and flexible learning goals that allow for different pathways and forms of demonstrating learning, such as replacing the goal “write a text by hand” with “produce a text,” thereby allowing the use of Assistive Technology (AT) when necessary.

At the same time, strategies and materials should be diversified to accommodate different forms of student engagement. Assessment, in turn, should be continuous and flexible, focusing on individual progress and the demonstration of learning regardless of the process used (Nunes & Madureira, 2015). Thus, the systematic integration of these components, guided by UDL principles, results in planning that goes beyond mere accommodation by promoting access, participation, and learning for all.

Beyond its practical application, it is important to consider the theoretical perspective guiding the implementation of UDL. In a systematic review, De la Fuente-González et al. (2025) identify three main approaches to UDL in teacher education: a clinical approach, which associates UDL with supporting students with special educational needs; a social/diversity-oriented approach, which views it as a framework for embracing diversity; and a critical approach, which advocates its use as an intersectional tool for dismantling structural systems of oppression and educational exclusion.

In this study, we adopt the critical perspective, which does not restrict the factors underlying exclusion to disability. This perspective rests on two pillars: (1) problematizing the norms through which “ability” and “disability” are conceptualized; and (2) incorporating an intersectional lens that recognizes the overlapping nature of multiple axes of oppression. Consequently, teacher education must equip teachers to identify these structural mechanisms of inequality, ensuring that the application of UDL genuinely fosters inclusive educational environments that are responsive to the particularities of each context (De la Fuente-González et al., 2025).

METHODOLOGICAL APPROACH

This study adopted a qualitative case study approach. According to André (2013), in educational research, this method examines a specific phenomenon in its uniqueness, actively considering the context in which it is situated and exploring its multiple dimensions.

The study was conducted as part of the elective course ‘Pedagogical Practice in Biology’, a 45-hour course offered in the Biological Sciences teacher education program at UNEB, *Campus* VII. Although the official course syllabus did not address the inclusion of people with disabilities, content on inclusive education was incorporated into the course plan in response to student demand, as the curriculum at the time did not include such discussions in initial teacher education.

Throughout the course, the prospective teachers engaged in the following activities: (a) theoretical study of inclusive education and UDL; (b) observation of pedagogical practices in classrooms and in the Multifunctional Resource Room (MRR) attended by students with disabilities; and (c) planning and teaching three Science lessons (150 minutes) based on UDL principles.

The study participants were three prospective teachers enrolled in the elective course 'Pedagogical Practice in Biology'. Course activities were carried out at a public basic education school recommended by the Municipal Center for Multiprofessional Assessment (CEMAM) in Senhor do Bonfim, Bahia, because it met the characteristics required for the study, namely, having an MRR staffed by a Specialized Educational Support (SES) teacher and students with disabilities enrolled in the final grades of lower secondary education.

The Science lessons were observed and subsequently taught in a sixth-grade class that included two students with disabilities. Of the 30 students in the class, one had Down syndrome and another had cerebral palsy, which affected his motor skills and speech articulation. Both received SES services in the MRR at the same school during the opposite school shift. Ravi (with cerebral palsy) and Isaac (with Down syndrome) were identified using pseudonyms to preserve their identities.

Data were collected using three complementary instruments: systematic observation, conducted and recorded by the researcher in field notes (Yin, 2016); reflective journals (Dias et al., 2013), kept by the prospective teachers throughout the observation stage; and semi-structured interviews conducted with the prospective teachers after completion of the course. To enhance the robustness and reliability of the analyses, we used data triangulation, a procedure that allows perspectives obtained from different sources and instruments to be cross-checked (Yin, 2016).

The research project was approved by UNEB's Research Ethics Committee (CEP/UNEB).¹ Participants were contacted only after this approval had been granted, and participation was formalized through the signing of an Informed Consent Form. For ethical reasons, their identities are protected through the use of the pseudonyms A1-, A2-, and A3- throughout the text. The numbers appearing after the hyphen correspond to the meaning units (Moraes & Galiazzi, 2011).

We analyzed the data using Discursive Textual Analysis (DTA), as described by Moraes and Galiazzi (2011). The *corpus* of analysis, composed essentially of textual materials, consisted of all data generated in the study: field notes, reflective journal entries, and interview transcripts.

We began the analysis by deconstructing the text, which generated "disorder from a set of ordered texts" (Moraes & Galiazzi, 2011, p. 21). We carried out this fragmentation process carefully to preserve fidelity to the participants' ideas. To this end, we retained key elements from each original excerpt, ensuring that the meaning units did not lose their context.

Next, we conducted careful and repeated readings of the deconstructed material to identify meaning units. Each identified unit was then isolated and fragmented according to the meaning it conveyed, subsequently giving rise to descriptive statements (Moraes & Galiazzi, 2011). Through this procedure, 35 meaning units were identified in the textual corpus.

We then proceeded to the stage of establishing relationships among these units. Through careful comparative examination of the data, we sought to identify emerging categories. As an initial result of DTA, we obtained nine categories, which were regrouped into broader categories (Moraes & Galiazzi, 2011), ultimately resulting in three final categories: (i) planning inclusive practice in Science

teaching; (ii) the inclusive learning environment; and (iii) the importance of inclusive practice in teacher education.

Finally, during the stage of capturing the emergent, we developed interpretive metatexts (Moraes & Galiazzi, 2011). In these metatexts, we articulated and further developed the final categories in order to communicate the new meanings constructed regarding the UDL-based teacher education process and its implications for teaching practice.

RESULTS AND DISCUSSION

In this section, we present and discuss the results organized according to the three final categories developed through DTA, relating the data generated in the study to the theoretical framework underpinning the research.

PLANNING INCLUSIVE PRACTICE IN SCIENCE TEACHING

Planning inclusive pedagogical practices requires careful attention to students and their individual characteristics. As Valle and Connor (2014) argue, teaching should, by its very nature, be personalized and designed around the particular characteristics of the students it serves. In the context of inclusion, this premise is fundamental, since students' different ways of processing sensory information and their diverse realities should serve as a starting point for teaching practice (Nunes & Madureira, 2015).

Throughout the study, the participating prospective teachers had the opportunity to characterize and analyze the context (Meo, 2008) during the observation stage, which involved pedagogical practices in classrooms and in the MRR attended by students with disabilities. Although the initial period of contact was brief, the prospective teachers conducted systematic observations and recorded their perceptions in reflective journals (Dias et al., 2013), which subsequently informed lesson planning (Meo, 2008).

In addition to the observations, the prospective teachers were given access, through the SES teacher, to the Individualized Education Plans (IEPs) of the students with disabilities, which were essential for tailoring pedagogical strategies. An IEP identifies the pathways that are most effective for a particular student and may suggest specific combinations of strategies, intensified support, or the use of AT to enhance access and participation (Valle & Connor, 2014).

The discussions with the SES teacher also provided an opportunity to challenge a culture of low expectations that discourages teachers in other subject areas from engaging with inclusion and leads them to repeatedly emphasize gaps in their own training (Silva & Massaro, 2022), overlooking the potential of collaborative work to strengthen teachers' knowledge and make inclusive classroom practices possible.

Guided by Meo's (2008) planning model, the prospective teachers defined clear learning goals that distinguished the content to be learned from the means used to achieve those goals. We then assessed the existing curriculum, identifying barriers in methods, materials, and forms of assessment that could restrict access.

This assessment informed the stage in which we applied UDL principles to create multiple means of representation, action, and expression. These options were then brought together in a unified lesson plan, ensuring that the planned flexibility resulted in a coherent learning experience accessible to all students.

Regarding the planning of UDL-based Science lessons, one of the prospective teachers reported:

The hardest part was planning the lesson because we're used to planning lessons without thinking that much about the students. We usually just plan around the content, and because this time we were working on an activity focused on inclusion and knew that there were two students with different disabilities, we tried to design something that would really allow them to participate in the same way as everyone else. (A2-14)

Based on this account, we can infer that, prior to the UDL-based experience, prospective teacher A2 planned lessons according to a traditional teaching model centered exclusively on content. A similar finding was reported by Prais and Vitaliano (2022), who also investigated UDL in teacher education. According to one of the participating teachers, "it was common to use the same activities every school year, such as relying solely on the textbook" (p. 8). This approach, which disregards students' characteristics and needs, is inherently exclusionary because it assumes the existence of a standard student who does not reflect the reality of the classroom. We understand that the "hardest part" (A2-14) described in the account does not represent failure, but rather an indication of professional learning. The prospective teacher's account reveals the cognitive and practical effort involved in breaking away from an internalized model and applying UDL principles.

Understanding of UDL principles is evident in the accounts of A2-14 and A1-2, the latter stating that lesson planning was intended to "meet the needs of everyone, including students who required a little more attention." This statement supports the argument by Sebastián-Heredero et al. (2022) that planning should ensure the equitable participation of all students, moving beyond the practice of *a posteriori* adaptations based solely on content. Thus, the starting point for planning shifts from the content itself to ensuring an accessible learning experience.

To provide all students with the opportunity to participate in the pedagogical intervention on the states of matter of water, teaching strategies and instructional materials were developed with the limitations and strengths of all students in the class in mind. The instructional proposal consisted of two complementary sessions: a 100-minute session devoted to constructing concept maps and a 50-minute session based on a themed version of the educational game "Battleship." By the end of the two sessions, students were expected to be able to identify the three states of water (solid, liquid, and gas) and provide everyday examples; name the changes of state of water (melting, freezing, vaporization/evaporation, and condensation); and connect these concepts within a network of meanings using a concept map. The activity was carried out in groups of five students, who had previously been instructed to respect each group member's pace and form of participation.

During the first session, after watching a video and taking part in a brainstorming activity on the topic, the groups completed concept maps prepared

on poster board using cards containing images, words, and linking terms. Ravi, a student with cerebral palsy, indicated where each card should be placed, while Isaac, a student with Down syndrome, was encouraged by his peers to match and attach the image cards.

Because the prospective teachers were aware of Isaac's reading difficulties and that he was also a student with an intellectual disability (ID), the concepts needed to complete the concept map were also presented through representative images. For example, the solid state was represented by images of an ice cube or a glacier; the molecular structure of water was likewise presented visually. Ravi, a student with cerebral palsy, was similarly able to participate independently by indicating the images and words that should be used to fill in the gaps in the concept map.

During the second session, the students worked with the educational game "Battleship," using a large board with coordinates and ships attached to the classroom board. Each group's turns involved drawing question cards that included image-based options for Isaac and objective response options for Ravi, who indicated answers and coordinates by pointing while his classmates verbalized them.

Throughout the sessions, the prospective teachers acted as facilitators: they moved among the groups, encouraged communication among students, and ensured that each student played an active role in the activities. Student participation took a variety of forms, combining speech, pointing, manipulation of images, and decision-making, thereby enabling students to express what they knew in different ways (Sebastián-Heredero et al., 2022).

Learning assessment was based on observation of the concept map (considering the number and relevance of the connections), collaborative performance during the game, and correct responses to the questions. Flexible assessment criteria were used: for Isaac, recognition of at least two changes of state of water and three visual examples; for Ravi, demonstration of understanding through accurate pointing, with no requirement for oral responses or handwriting.

According to the observations conducted during the activity, providing multiple means of representation, action, and expression enabled students with disabilities to contribute their views on conceptual relationships during the group activity, often identifying those relationships correctly.

Regarding the activity, prospective teacher A3 stated:

What made the concept map different was the images. We brought in a selection of images that they could look at and relate to the concepts, depending on what was being asked. Teachers do not usually work with images alongside the questions; generally, when they ask a question, they expect the answers to be given only in written form. (A3-19)

A3's statement illustrates the implementation of pedagogical planning guided by UDL principles and the corresponding flexibility of the curriculum. The account reflects a practice that departs from the traditional teaching model by offering multiple means of representing information and expressing knowledge, both of which are fundamental to the development of an inclusive educational environment (Meo, 2008).

More specifically, the strategy of using images associated with concepts in the concept map aligns with the UDL principle of *multiple means of representation* (Sebastián-Heredero et al., 2022). By supplementing or replacing written language with visual representations, the activity removes barriers to accessing content for many students. This approach benefits not only Isaac, a student with Down syndrome, but also students who rely more heavily on visual modes of learning, those with reading difficulties, and those with different levels of language proficiency.

At the same time, allowing students to associate images with concepts rather than requiring an exclusively written response aligns with the principle of *multiple means of action and expression* (Sebastián-Heredero et al., 2022). This instructional design provides varied pathways through which students can demonstrate understanding and engagement, valuing different forms of cognitive processing and communication. In this way, intentionally flexible planning promotes greater autonomy and enables each student to draw on their strengths to construct and demonstrate their learning.

The prospective teacher's critical observation that this type of practice is not customary, expressed in the statement "Teachers do not usually work with images" (A3-19), highlights the paradigm shift proposed by UDL. It shows that inclusive education is not limited to simply adding resources but instead requires instructional restructuring that anticipates human diversity in the classroom from the outset and plans accordingly. Thus, the "difference" identified in the experience extends beyond the playful nature of the activity and constitutes the pedagogical mechanism that ensured equitable access, participation, and expression, providing a clear example of how UDL principles, when translated into planning and concrete instructional materials, can give practical form to inclusive pedagogical practices.

THE INCLUSIVE LEARNING ENVIRONMENT

In an inclusive learning environment, collaboration is not merely a pedagogical resource but a foundation for knowledge construction (Valle & Connor, 2014). Working in small, diverse groups can transform education by fostering autonomy, cooperation, shared responsibility, appreciation of teamwork, and recognition of the diversity of human talents (Mantoan, 2003). However, Edyburn (2010) reminds us that not every conversation among students constitutes collaborative learning.

According to Mantoan (2003), "quality teaching exists when educational actions are grounded in solidarity, collaboration, and the sharing of the educational process with all those directly or indirectly involved in it" (p. 34). In this sense, collaborative work and mediated dialogue not only facilitate conceptual learning for all students but also transform differences into opportunities for mutual learning, whereby the support provided to overcome a challenge ultimately contributes to everyone's development (Santos & Duarte, 2019).

In our analysis of the data, we identified the following accounts concerning interaction among students during the learning process:

It was actually really interesting to see the support the classmates gave the students with disabilities. That willingness to help, that sense of camaraderie, was interesting. (A1-04)

So, they [pause] from the moment they started filling in the concept map so they could move on to the second game, they engaged in critical thinking and put into practice the knowledge that had already been addressed in class, before we did the game. And it also helped a lot with logical reasoning because, among themselves... they discussed things; each one had an opinion, and they discussed what should be placed at each point, according to the figure, the image, or the text. (A2-11)

A1-04's account, by emphasizing the "support the classmates gave the students with disabilities" and the "sense of camaraderie," captures the essence of collaborative work. We agree with Mantoan (2003) that educational environments with these characteristics promote appreciation of differences through peer interaction, replacing competitiveness with a spirit of solidarity and participation. Such educational settings ensure that everyone has the opportunity to learn in mainstream, heterogeneous classrooms.

A2-11's account, in turn, provides a detailed description of the collaborative process of knowledge construction. Completing a concept map as a group in preparation for a game created a setting conducive to learning. The statement that "they discussed things; each one had an opinion, and they discussed what should be placed at each point" shows that knowledge was not simply transmitted but collaboratively constructed.

In diverse contexts, this dynamic is particularly powerful because it brings together different ways of perceiving the world, including through images and text, ensuring that multiple perspectives are considered and that all students, regardless of their starting point, have an active voice in the learning process. We agree with Santos and Duarte (2019), who state that group activities promote inclusion and that "the contributions of this type of work relate to a sense of belonging, acceptance and support, cooperation, empathy, and the ability to work in groups, all of which are essential values in the inclusion process" (p. 57).

A perception shared by participant A3 during the teaching and learning process, expressed in the statement "they thought that students with disabilities were not 'capable,' in quotation marks, of working with the content in the same way as students without disabilities, so that was a positive point" (A3-17), reveals a pedagogical experience with the potential to help students deconstruct ableism. The account reflects a belief that normalized low expectations regarding the academic potential of students with disabilities, thereby restricting their access to the common curriculum (Crochick, 2013). The prospective teacher's critical recognition of this prejudice, marked by the quotation marks around the word "capable," signals a conscious break with this exclusionary logic.

This account supports Crochick's (2011) perspective that contact among people from different backgrounds in school settings can serve as an antidote to prejudice. Within this logic, the experience designed by the prospective teachers moves students with disabilities away from a marginalized position in the classroom by enabling greater autonomy and empowerment through participation in the activities (Crochick, 2011). At the same time, collaboratively developing an inclusive pedagogical practice has the potential to broaden students' understanding of and respect for different ways of being and living in the world.

The "positive point" (A3-17) identified lies precisely in overcoming this stereotype. In this specific case, the practical experience demonstrated that the

barrier to learning was not intrinsic to the student but rather produced by traditional and inflexible pedagogical practices. UDL provides the theoretical and practical framework for this transformation by proposing that planning take human variability into account from the outset through multiple means of engagement, representation, and action and expression. In this way, the focus shifts from the student's supposed "inability" to the school's responsibility to remove barriers and provide diverse learning pathways.

The account therefore encapsulates an essential formative process: the shift from internalizing prejudice to critically recognizing it (Crochík, 2011). This trajectory reinforces the need for teacher education that combines theoretical reflection on mechanisms of oppression, such as ableism, with practical experiences structured around inclusive pedagogical frameworks such as UDL. Only in this way can we prepare teachers to act as active agents in the development of educational environments that not only welcome diversity but also value and foster it while challenging exclusionary structures.

THE IMPORTANCE OF INCLUSIVE PRACTICE IN TEACHER EDUCATION

Experiencing inclusive practice during initial teacher education is essential for preparing teachers who are able to promote democratic and equitable schooling. However, its implementation faces obstacles ranging from curricular structures to insufficient preparation among teacher educators themselves (Vilela-Ribeiro & Benite, 2013). Thus, although legislation guarantees access to and continued enrollment in basic education, truly inclusive education depends on teachers who are prepared to address difference and diversity in the classroom.

It is worth recalling that this teacher education initiative emerged from the prospective teachers' expressed need to feel prepared to teach classes that include students with disabilities. A2-05's account—"For me, this work with inclusion is very important because we always encounter people with disabilities during our teaching practicum and, regardless of the disability, we didn't know how to include them in the activities"—reveals a sense of practical insecurity when faced with classroom diversity. The statement "we didn't know how to include them in the activities" also highlights the gap that often exists between discussions of inclusive education and the ability to translate them into effective pedagogical action in the classroom.

In this context, the experience of teaching Science in classrooms that included students with disabilities, based on UDL, enabled the development of teaching competencies centered on valuing differences and using approaches responsive to students' individual characteristics. Regarding their experience of inclusive practice, we highlight the following accounts from the participants:

The experience was very enriching, mainly because every experience is unique, and this one gave me such a wealth of feelings from being there at that moment, building learning together with all the students, not just the students with disabilities. (A1-09)

So, working with this content on inclusive education is important for my education because it will help me be prepared to face the classroom when I begin teaching, and I'll know how to design and plan an activity that helps all my students construct their knowledge, regardless of the disability each one may have. (A3-06)

The experience reported by the prospective teachers represents a fundamental and transformative element in their preparation for inclusive teaching. By describing the experience as “very enriching” because it involved “building learning together with all the students,” A1-09’s account provides evidence of movement beyond a medical and segregation-oriented model of inclusion. This statement reflects an understanding that UDL is not a strategy intended for a specific group but rather a curricular approach that benefits everyone, creating a learning community in which difference forms the basis of the educational process, as Meyer et al. (2014) argue when they state that student diversity should guide pedagogical practice.

The experience described therefore emerges as essential to the development of professional competence. Edyburn (2010) argues that UDL should be understood as a competency to be developed, which requires opportunities for application and reflection on the relationship among goals, student characteristics, and strategies. The practical experience enabled the prospective teachers to move beyond a reactive and improvised approach and experience proactive planning that, grounded in UDL principles (CAST, 2024), anticipates and removes barriers.

Taken together, the two accounts illustrate a formative trajectory that begins with recognition of the lack of opportunities within their own teacher education to work with students with disabilities and progresses toward an understanding of UDL as a curricular approach that restructures practice for the benefit of all. This trajectory reflects the need identified by De la Fuente-González et al. (2025) for UDL-based teacher education to adopt critical and social approaches that prepare prospective teachers not only to adapt activities but also to question exclusionary curricular structures and create learning environments that are inherently equitable and accessible from the outset.

The participants’ accounts also reveal that the experience with inclusion operates at two complementary levels that are critical to their professional development: the pedagogical-methodological level and the cultural-institutional level. Both point to structural gaps in teacher education and to the potential of UDL-based preparation. Regarding the importance of discussions about inclusive education, participant A2 stated:

Because, generally, teachers who teach the subject [Science] use the traditional method, which is the board and explaining the content; other approaches are not used in the classroom. (A2-08)

And the other teachers, she said, from the other classes, also wanted to learn about the work. So, working with inclusive education is very important to me because people are still not prepared to deal with this issue. (A2-13)

The first account (A2-08) expresses a critique of the prevailing teaching model, characterized as “traditional” and limited to “the board and explaining the content.” This observation identifies the source of pedagogical exclusion: uniform teaching centered on verbal transmission and disconnected from the diversity of ways in which students learn. The prospective teacher’s statement suggests that the experience with inclusion led to recognition of the need for “other approaches in the classroom,” anticipating the core of UDL: providing multiple means of

engagement, representation, and action and expression to address student diversity (CAST, 2024).

The second account (A2-13) broadens the analysis beyond the classroom and shifts the focus to the school community. The interest shown by other teachers indicates that successful inclusive practices grounded in principles such as those of UDL can have both a demonstrative and a disseminating effect. However, the prospective teacher's conclusion that "people are still not prepared to deal with this issue" reflects a perception that the school community as a whole is insufficiently prepared to work in diverse contexts. This statement is consistent with Edyburn's (2010) perspective that the transition to a flexible curriculum requires not only specific preparation at the individual teacher level but also changes in school culture. The account shows that inclusion is not a technique to be applied in isolation but a collaborative project that requires a shift in mindset and the sharing of knowledge among peers (Mantoan, 2003).

In summary, the accounts show that discussing and practicing inclusion during initial teacher education played a dual role. First, they challenged the taken-for-granted status of exclusionary pedagogical practices by revealing the limitations of traditional teaching in addressing diversity. Second, they positioned prospective teachers as agents of cultural change within the school, aware of their role not only in supporting learning in their own classrooms but also in potentially influencing their colleagues' practices. The experience described is therefore consistent with the critical approach to UDL (De la Fuente-González et al., 2025), which advocates teacher education capable of questioning norms and structures and positioning teachers as transformative intellectuals who are prepared to address diversity and progressively foster a more inclusive and accessible school culture.

FINAL CONSIDERATIONS

The experience of planning and implementing an inclusive pedagogical practice in Science teaching grounded in UDL principles proved to be a meaningful learning experience for the participating prospective teachers. The findings show that inclusion, when conceived as an intentional curricular approach, goes beyond isolated adaptations and has the potential to transform classroom dynamics, students' relationship with knowledge, and teachers' own professional identities.

The findings also showed a shift from planning centered exclusively on content transmission to planning centered on providing a learning experience accessible to all. The initial difficulty reported by the prospective teachers in moving away from the traditional model reflects the challenges inherent in this necessary shift. Nevertheless, the process led to an understanding that curriculum flexibility is not an additional feature but rather a foundation of inclusive teaching.

The prospective teachers' practical experience highlighted the fundamental role of collaboration as a means of fostering inclusion and cognitive development. The interactions observed among students, characterized by mutual support and the dialogic construction of knowledge, demonstrated that an inclusive environment can enhance learning across the entire group. More significantly, the practice challenged ableism by confronting stereotypes and enabling both

students and prospective teachers to witness the academic capabilities of all learners when appropriate support is provided.

The prospective teachers' accounts highlight the importance of reflective practice on inclusive education during initial teacher education. Within the context of this study, the experience contributed to narrowing the gap between theory and teaching practice, enabling uncertainty about teaching diverse groups of students to be transformed, albeit within the scope of this specific experience, into greater pedagogical competence. The positive response to the work among other teachers at the school, as reported by the participants, further indicates the potential of these prospective teachers to act as agents for disseminating an inclusive school culture.

Finally, we acknowledge the limitations inherent in the methodological scope adopted, the brief duration of the intervention, and the specificity of the context. These temporal and contextual constraints prevent the data from supporting inferences about consolidated or lasting changes in the development of teacher identity, limiting our conclusions to context-specific reflective shifts and preventing the observation of possible long-term effects on the prospective teachers' pedagogical practice.

Nevertheless, we believe that these limitations do not diminish the relevance of the study. On the contrary, we reaffirm its contribution as a case study that highlights the formative potential of short, intensive experiences, providing indications for the critical reconsideration of beliefs and for planning future interventions in similar contexts, while maintaining the interpretive caution required by the scope of the data. Further research on UDL in the education of Science and Biology teachers is urgently needed. We believe that deeper theoretical and practical engagement with UDL can contribute to the development of inclusive curricula and pedagogical practices, thereby ensuring all students' right to high-quality Science education.

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