PRÁTICAS EDUCATIVAS, MEMÓRIAS E ORALIDADES

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# Pedagogical notebook: training episodes for mathematics education guided by the principles of universal design for learning

**PEDAGOGICAL PRODUCT**

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**Abstract**
This text will communicate part of the results of a Master's research in Inclusive Education, entitled: “Training to include” Mathematics Education in interface with Universal Design for Learning. Thus, this work aims to present an educational artifact (pedagogical notebook modality) as an instrument for the elaboration of proposals for training, innovation and curricular differentiation, whether in teacher training or in the planning of school Mathematics through the assumptions of Universal Design for Learning (UDL). To this end, in the collaborative action research developed with undergraduate students in Mathematics, we used the Design Science Research method to elaborate the educational product and produce new knowledge. Thus, we analyzed a sequence of recurring actions, as pointed out by Dresch, Lacerda and Antunes Júnior (2015). As results, for the development of innovation, we can highlight its contribution to the improvement of pedagogical attitudes with expanded dimensions, in relation to autonomy, criticality and reflective process; for scientific development, its contribution to pedagogical and technological mediation from an inclusive perspective and in interface with the UDL; and for technological development, potential of educational processes and products for the field of teacher training from an inclusive perspective.
**Keywords:** Educational Product. Teacher Training. Mathematics Education. Universal Design for Learning.

## Caderno pedagógico: episódios formativos para educação matemática orientados pelos princípios do desenho universal para aprendizagem

**Resumo**
Neste texto será comunicado parte dos resultados de uma pesquisa de Mestrado em Educação Inclusiva, intitulada: “Formar para incluir” Educação Matemática em interface com o Desenho Universal para Aprendizagem. Assim, este trabalho tem como objetivo apresentar um artefato educacional (modalidade caderno pedagógico) como instrumento para a elaboração de proposições de formação, inovação e diferenciação curricular, seja na formação do professor, seja no planejamento da Matemática escolar através dos pressupostos do Desenho Universal para Aprendizagem (DUA). Para tal, na pesquisa-ação colaborativa desenvolvida com licenciandos em Matemática, utilizamos o método *Design*

*Science Research* para a elaboração do produto educacional e produção de novos saberes. Dessa forma, analisamos uma sequência de ações recorrentes, conforme apontado por Dresch, Lacerda e Antunes Júnior (2015). Como resultados, para o desenvolvimento de inovação, pode-se destacar sua contribuição para o aperfeiçoamento de atitudes pedagógicas com dimensões ampliadas, em relação a autonomia, criticidade e processo reflexivo; para o desenvolvimento científico, sua contribuição para a mediação pedagógica e tecnológica na perspectiva inclusiva e em interface com o DUA; e para o desenvolvimento tecnológico, potencialidades de processos e produtos educacionais para o campo da formação de professores na perspectiva inclusiva.
**Palavras-chave:** Produto Educacional. Formação de Professores. Educação Matemática. Desenho Universal para Aprendizagem.



## 1 Introduction

In the act of teaching, there is likewise something to learn—in other words, these are two fundamental and interrelated processes of the teaching profession: “those who teach learn by teaching, and those who learn teach by learning. Whoever teaches, teaches something to someone” (Freire, 2021, p. 23). One cannot teach what one does not know, and even with knowledge, it is still necessary to continue learning. Thus, these specific and inseparable processes, which occur in heterogeneous contexts of cultural diversity, are embedded in a dialectic that enhances the contextualization and problematization of the act of teaching and learning—resulting in a condition of protagonism. Therefore, to include, it is necessary to educate and to be educated.

In this regard, the first author developed a Master's research project in the Graduate Program in Inclusive Education at the State University of Paraíba (Universidade Estadual da Paraíba-UEPB), entitled “Educating to Include”: Mathematics Education in Interface with Universal Design for Learning. The main objective of the study was to analyze the contributions resulting from the implementation of a formative design in the field of Mathematics Education through the development of formative episodes guided by the principles of Universal Design for Learning (UDL).

To this end, collaborative action research was employed. Mion and Bastos (2001, p. 32) highlight the value of action research, stating that "by researching educational practice and reflecting on it, we begin to perceive how it occurs, allowing us to redirect it. We reflect on practice in order to judge it and thus seek new practices and attitudes." Pimenta (2005) argues that collaborative research is an important process to address the dichotomy between researchers and participants and that it must be structured as an action research project. From this perspective, collaborative action research must be understood as "an open-ended process: each project constructs its own paths based on the general problem and the specific questions related to its investigation" (Pimenta, 2005, p. 14).

This article presents part of the results obtained through the proposal of an educational artifact in the form of a pedagogical notebook, conceived as an instrument for the development of propositions aimed at teacher training, curricular innovation, and differentiation—both in teacher education and in the planning of school mathematics, based on the principles of UDL.

The term *artifact*, derived from the Latin *arte* + *factus*, refers to something created with skill and technique. According to Pimentel, Filippo, and Santos (2020), an artifact can be defined as a deliberately and artificially constructed device, created for a specific purpose, resulting from a planning process; it may be a product that is not limited to material objects but may also include intangible intellectual creations, such as a teaching activity.

Rosa and Locatelli (2018) add that educational products are also based on theoretical foundations for their development. Therefore, the objective of this study is to present the methodological process used in the production of the artifact, titled *Pedagogical Notebook: Formative Episodes for Mathematics Education Oriented by the Principles of Universal Design for Learning*.

Accordingly, we analyze a sequence of actions as described by Dresch, Lacerda, and Antunes Júnior (2015), in their discussion on methods for implementing *Design Science Research* (DSR), which is defined as a methodology with two

objectives: to create an artifact that addresses a practical problem in a specific environment and to produce new technical and scientific knowledge (Pimentel; Filippo; & Santos, 2020).

## 2 The Design Science Research Method



According to Oliveira, Santos and Florencio (2019), practical demands that require interdisciplinary articulation between subjects and research contexts go beyond traditional academic boundaries. Regarding the Educational Design approach, within the field of Design Science—"a science that aims to prescribe a solution and can assist in bridging the gap between theory and practice" (Dresch, 2013, p. 74)—the method used in this study was Design Science Research (DSR). DSR is recognized as an emerging and relevant approach for various investigations in the educational field, which "can be developed to meet a variety of objectives, including both the improvement of the teaching-learning process and the optimization of administrative and managerial tasks" (Madureira; Galvão; Schneider, 2025, p. 21).

As an evolving type of research, DSR can significantly contribute to the creation of educational prototypes and artifacts that are genuinely relevant (Angeluci *et al*., 2020). As stated by Pimentel, Filippo and Santoro (2020), DSR is a methodology that, in addition to generating scientific knowledge about reality, also aims at creating a new reality—transformed through the design of artifacts intended to solve specific problems in given contexts.

Pimentel, Filippo and Santoro (2020) highlight the potential of DSR as an epistemological-methodological strategy that enables the execution of rigorous scientific studies linked to the creation of innovative artifacts. According to the authors, DSR, like action research, fits within pragmatism—an epistemological (meta)paradigm that seeks not only to understand and explain reality, but to transform and reimagine it.

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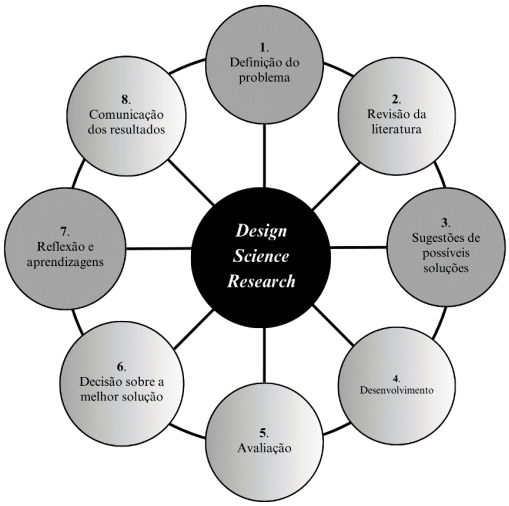
As stated by Pimentel, Filippo and Santos (2020, p. 42): “there are different proposals for conducting research using DSR. In general, these approaches aim to achieve a dual objective: to develop an artifact and to generate technical-scientific knowledge.” Thus, although there is no single, universally accepted method for conducting research under the DSR approach (Pimentel; Filippo; Santoro, 2020), Dresch, Lacerda and Antunes Júnior (2015)[1] mention that some common stages can be found among the various methods, as illustrated in Figure 1.



**Figure 1 – Recurring stages in research using the Design Science Research method**




Source: Santos (2024, p. 174), based on Dresch, Lacerda and Antunes Júnior (2015).

The first stage consists in the definition of the problem. From the relevance of the study, a significant issue is identified or a solution is proposed to a problem or a class of problems. Data is also gathered to understand the context, considering both the potential of the artifact and the necessary requirements for its functioning.

[1] The protocol proposed by Dresch, Lacerda and Antunes Júnior (2015) includes twelve stages: from the identification and awareness of the problem to the literature review, proposition, development, and evaluation of the artifact, concluding with lessons learned, conclusions, generalizations, and the communication of results.

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> In the field of education, this activity is often closely related to the lived experience of the researcher—whether as a student, teacher, or administrator. Upon identifying a situation, one should consider whether an artifact could bring improvements to that specific context. This identification must be accompanied by a careful analysis of the needs and challenges of the educational environment in order to ensure that the artifact is both relevant and applicable (Madureira; Galvão; Schneider, 2025, p. 21).



The second stage involves a systematic literature review, aimed at contextualizing key knowledge for solving the problems and designing the artifact. In other words, it refers to identifying existing artifacts and defining the classes of problems, in order to make a meaningful contribution to a specific class. Another important stage is suggesting possible solutions—this is when the artifact is proposed within a particular context, taking its feasibility into account.

Next is the artifact development stage, which involves the implementation of approaches capable of fostering knowledge applicable to solving the identified problems.

> Development refers to the actual creation of the artifact and requires the application of technical knowledge, specific tools, and appropriate methodologies to transform planned ideas into a functional product. It is important to emphasize that this is an iterative process: adjustments may be required as new demands or challenges emerge during the construction phase. This flexibility is crucial to ensure that the artifact fully meets the expectations and needs identified in the initial problem (Madureira; Galvão; Schneider, 2025, p. 30).

The artifact evaluation stage may take place in either an experimental or real-world setting, in which the requirements defined during problem formulation are compared with the results obtained. Madureira, Galvão and Schneider (2025, pp. 39–40) support this perspective by detailing common strategies and tools used in the educational field. As an example, they highlight that “action research can also be integrated into a project developed through DSR [...]”, since it shares with DSR the objective of producing concrete impacts on practices and reality.

In the sixth stage, the lessons learned and conclusions are presented, allowing the study to serve as a repertoire for promoting both theoretical and practical knowledge. The penultimate stage is dedicated to reflection and learning through the

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generalization of findings to a broader class of problems. Finally, the communication of results takes place, which is of great importance to ensure broader access for those interested in the field of study and the topic investigated.

## 3 The educational product



### 3.1 Stage 1: Problem definition

> […] whenever we are dealing with the human dimension, it is necessary to consider human diversity, acknowledging all the contradictions involved in what it means to be human. Thus, we ask ourselves: how can we produce theory in the educational field that allows us to encompass different facts? It seems that, as we delve into the discussion, rather than finding answers, we encounter issues to be posed and discussed; doubts emerge that further complicate the attempt to encompass and conceptualize this relationship (Mezzarobai; Carriquiriborde, 2020, p. 4).

Mathematics Education is understood as

> a broad field of educational research whose object of study is the understanding, interpretation, and description of phenomena related to the teaching and learning of mathematics at various levels of schooling, whether in its theoretical or practical dimensions (Pais, 2002, p. 10).

It is worth noting that Mathematics Education is considered a relatively new field in Brazil, with the founding of the *Sociedade Brasileira de Educação Matemática* (Brazilian Society of Mathematics Education) in 1988. Today, it is a well-established area that actively participates in decisions concerning the development of mathematics teaching and learning processes in the country.

At the core of inclusive education, investing in teacher training is essential, as mere discourse about student access—within pedagogical practices weakened by working conditions and poor training—only increases the gap from a genuine movement of inclusion in schools.

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As an illustration, in 2013, a group of mathematics educators created GT13 – *Working Group on Difference, Inclusion and Mathematics Education*, linked to the Brazilian Society of Mathematics Education. According to these educators, it is essential to value the active contribution of all students, taking into account their potential. In their research, "studies are intended to contribute to the development of a Mathematics Education that promotes a deeper understanding of teaching and learning processes, focusing on theoretical, methodological, pedagogical, and epistemological issues" (Nogueira et al., 2019, p. 7).

In this regard, Déa, Rocha, and Déa (2018) encourage us to (re)interpret our pedagogical practice in opposition to exclusion, recognizing people as unique individuals with different abilities and limitations. Accordingly, Miskalo, Cirino, and França (2023) highlight that inclusion is a process in constant evolution—just like teacher education.

Furthermore, considering the contributions of applying Universal Design for Learning (UDL) in formative spaces—understood as structured and meaning-filled environments (Prais, 2016; Zerbato, 2018; Oliveira, 2021)—the following research question was defined: *How can the UDL approach contribute to the formative process of future Mathematics teachers, in interface with Mathematics Education?*

The supporting sub-questions are as follows: What do the studies reveal about the appropriation of UDL in the field of Mathematics Education?; What are the components of UDL planning in interface with Mathematics Education?; What are the contributions of UDL to the initial training of Mathematics teachers in the context of inclusive education?

For this purpose, UDL is approached in this study as a perspective to enhance formative and learning environments that are flexible, diverse, personalized, and inclusive. This approach, grounded in learning *for and with all*, encompasses three key principles: multiple means of engagement (the *why* of learning); multiple means of representation (the *what* of learning); and multiple means of action and expression (the *how* of learning) (Meyer; Rose; Gordon, 2014).

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### 3.2 Stage 2: Literature review



The systematic literature review (SLR) is an increasingly common method in scientific research for evaluating a body of data simultaneously. It is widely recognized in academic settings for its ability to incorporate the results of individual, well-established studies, enabling the objective synthesis of scientific knowledge. According to Campos, Caetano and Laus-Gomes (2023), although still underutilized in the field of education, there has been a global increase in the adoption of this research strategy and in the benefits it brings to the accumulation of knowledge.

The protocol used in this SLR followed four stages (Figure 2): (1) the planning of the systematic review, which included defining the study and presenting the guiding research questions; (2) the analysis of scientific output based on exclusion/inclusion criteria, considering the parameters of source (database), theme (descriptors), chronology (time frame), and language (object of study); (3) the cataloging of the studies by presenting a bibliographic portfolio; and (4) through the organization of working groups (categories), the qualitative analysis of the bibliographic portfolio (descriptive and analytical synthesis), aimed at answering the predefined guiding questions (reflective synthesis).

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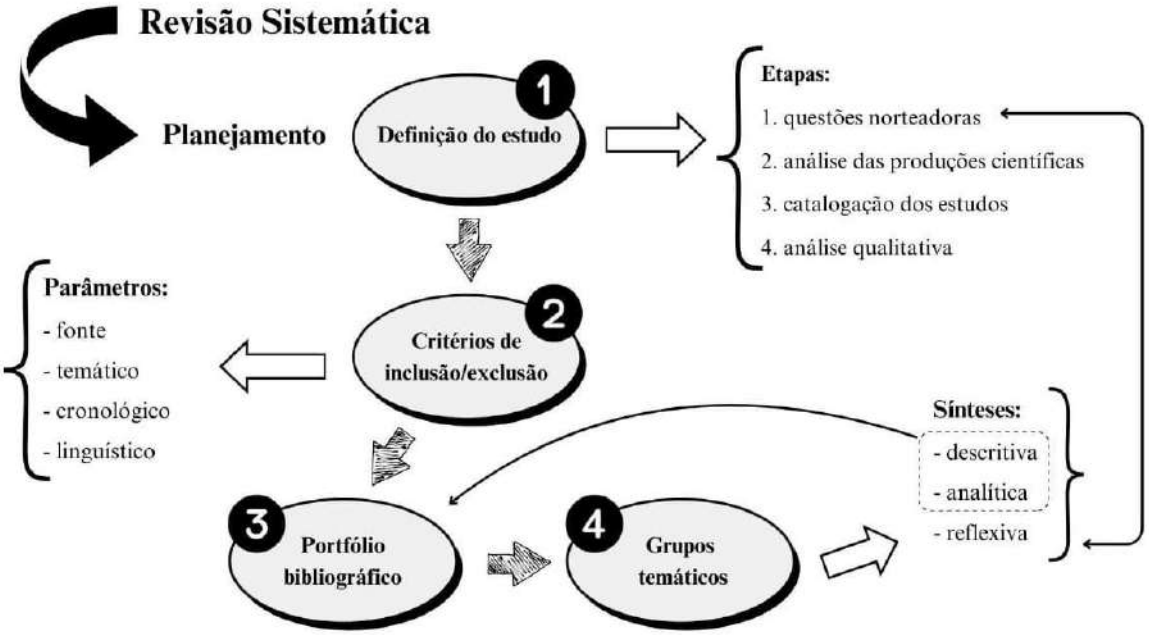
**Figure 2 – SLR Protocol**




Source: Santos (2024, p. 40).

The document search was carried out in June 2024. Regarding the *source parameter*, the following databases were investigated: the CAPES Journal Portal (*Portal de Periódicos da Capes*), the CAPES Theses and Dissertations Catalog (*Catálogo de Teses e Dissertações da Capes*), and the Brazilian Digital Library of Theses and Dissertations (BDTD). As for the *thematic parameter*, the following search descriptors were used: “Universal Design for Learning” (along with its variations in Portuguese: *da, para, na, de*) and “Mathematics.” For the *chronological parameter*, the period 2021–2023 was selected. Regarding the *linguistic parameter*, the selection prioritized texts written in Portuguese. A total of 18 studies were identified (10 master's theses and 8 articles).

The SLR revealed that UDL has been cited as a perspective that offers guiding principles for promoting and/or expanding the process of educational inclusion. Although the search returned a reasonable number of studies, the application of the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selection criteria showed that most national academic output focuses on analyzing the consequences of implementing UDL principles in basic education—particularly in studies involving the design or use of UDL-based teaching objects—rather than investigations into its application in teacher education.

In summary, the studies demonstrate the qualitative potential of UDL's applicability. Nonetheless, this research provided insights to contextualize the scenario of inclusive Mathematics Education from a UDL perspective within Brazilian academic output, as well as to identify theoretical and practical aspects related to the potential implementation of UDL in the educational process aimed at inclusive pedagogical practices.



### 3.3 Stage 3: Suggestions for possible solutions

Based on the model of intermediate pedagogical processes in action research (Ghedin & Franco, 2011), we proposed a formative arrangement from the perspective of learner-centered instructional design (Filatro, 2023). According to Calegari, Silva and Silva (2014, p. 44), the instructional design model that best aligns with the principles of UDL is the contextualized one, as it takes into account students' specific contexts and "allows for the personalization and flexibility of teaching plans, given that it accepts adaptable and pre-programmed resources."

Figure 3 illustrates the proposed formative design. UDL guides reflection in practice and equips teachers for more inclusive pedagogical and technological mediation. According to Castro, Mill and Costa (2022, p. 2), pedagogical mediation "is an action within the teaching and learning process aimed at constructing knowledge, in a continuous movement that unfolds in multiple settings." Technological mediation, in turn, is understood as:

> a process of planning and organizing teaching, taking into account pedagogical goals and intentions, in order to incorporate technologies [...] into the teacher's actions, in constant dialogue with the pedagogical mediation process (Oliveira; Silva, 2022, p. 12).

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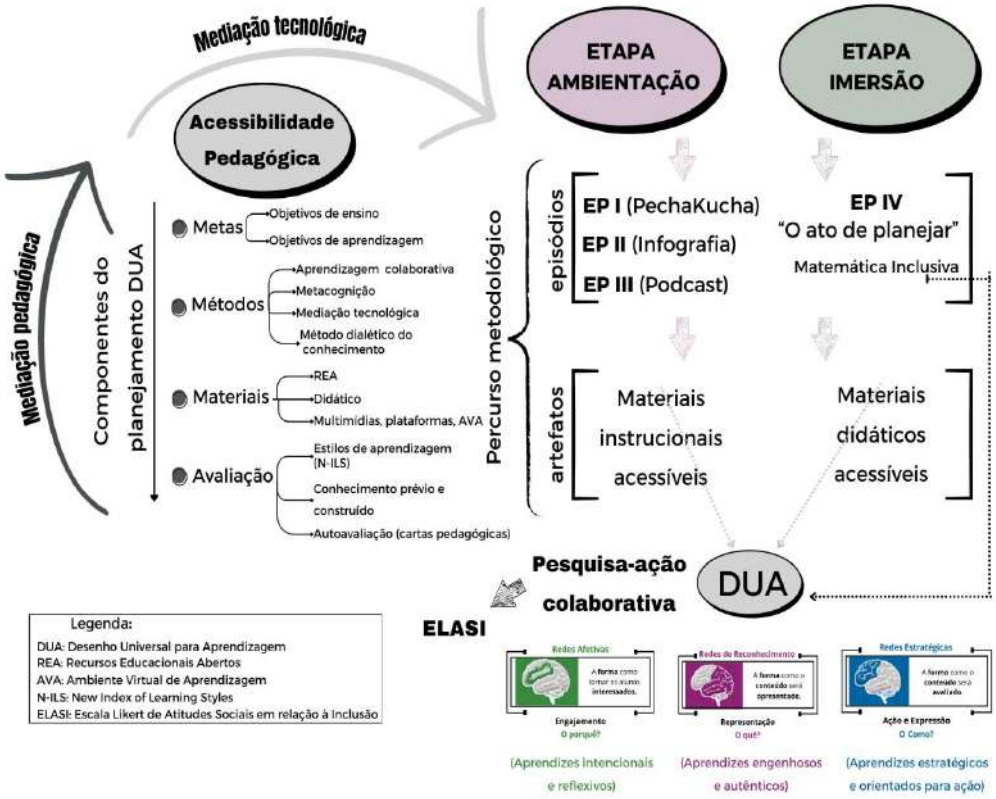
**Figure 3 – Formative design guided by the principles of UDL**




Source: Santos (2024, p. 106).

According to Sebastián-Heredero (2020, p. 738), "four highly interrelated components make up the UDL curriculum: goals, methods, materials, and assessment." Goals refer to the teacher's expectations regarding student learning. Methods refer to the pedagogical tools used to develop the teaching and learning process. Materials refer to the resources employed to present learning objects. Assessment refers to the processes of monitoring and providing feedback on student performance.

To achieve these goals, specific teaching strategies were adopted. The main actions throughout the formative path included: encouraging collaboration aimed at the

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enhancement and expansion of competencies in a meaningful way, directly impacting learning; offering opportunities for each student to express their skills in diverse ways, recognizing and valuing different student profiles; and promoting an inclusive environment that fosters engagement through the stimulation of self-regulation, self-determination, and autonomy, thus strengthening active student agency in the learning process.



- **Teaching Goal 1:** To promote students' engagement in a welcoming and empathetic formative context, guided by the principles of UDL, where each student feels respected and valued in their individuality and where collective construction is encouraged so that all can (re)signify and (trans)form the political objective of inclusive education through active agency committed to educational equity.
- **Learning Goal 1:** To understand conceptual, historical, philosophical, social, cultural, legal, political, educational, didactic, and pedagogical aspects of special education and the unfolding processes of educational exclusion and inclusion of students eligible for special education services. According to Prais (2016, p. 76), "it is up to teacher education programs, both initial and continuing, to provide the theoretical and practical knowledge necessary for implementing educational inclusion in intentions (planning) and pedagogical practices (action guided by planning)."
- **Teaching Goal 2:** To foster students' immersion in a professional formative context, where each participant enhances collaborative action through the competence of instructional planning that contributes to the development of critical, reflective, creative, and original processes aligned with the principles of inclusive education.
- **Learning Goal 2:** To integrate disciplinary, pedagogical, curricular, technological, experiential, and socio-emotional knowledge for planning inclusive school mathematics teaching guided by the principles of UDL. Teaching planning is understood as "an indispensable action for teaching


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practice, an activity of research and study, a forecast of actions, a pedagogical evaluation of teaching and learning, and a reflection on what, why, and how to teach" (Prais, 2016, p. 76).



To develop these methods, it was necessary to provide broad teaching and learning experiences. In this sense, the main methods adopted throughout the formative path were: collaborative learning, technological mediation, the dialectical method of knowledge (Vasconcellos, 1992), and metacognition. In defining materials, two categories of technologies were considered: analog and digital. Regarding assessment, the main processes used were: learning styles (Felder; Silverman, 1988; Felder; Soloman, 1991), prior and constructed knowledge, and self-assessment.

### 3.4 Stage 4: Development

Formative episodes are understood as educational instances that reveal the connection between the components of a training activity. According to Moura (2004, p. 267), they are characterized as "written or spoken phrases, gestures, or actions that constitute scenes which may reveal the interdependence between elements of a formative action."

Accordingly, the formative design proposed as a suggested solution was implemented in the curricular component Methodology Applied to Mathematics Education in Inclusive Education, part of the Mathematics Teaching Degree program at the Federal Institute of Paraíba, Cajazeiras campus, during the second semester of 2023, with the participation of 28 undergraduate students.

In the immersion stage, the processes and products (accessible instructional materials) developed in the first three formative episodes sought to respond, through the use of PechaKucha, to the question What is school inclusion? (Figure 4); through the infographic Why school inclusion? (Figure 5); and through the podcast How to implement school inclusion? (Figure 6). In the immersion stage, through the practice

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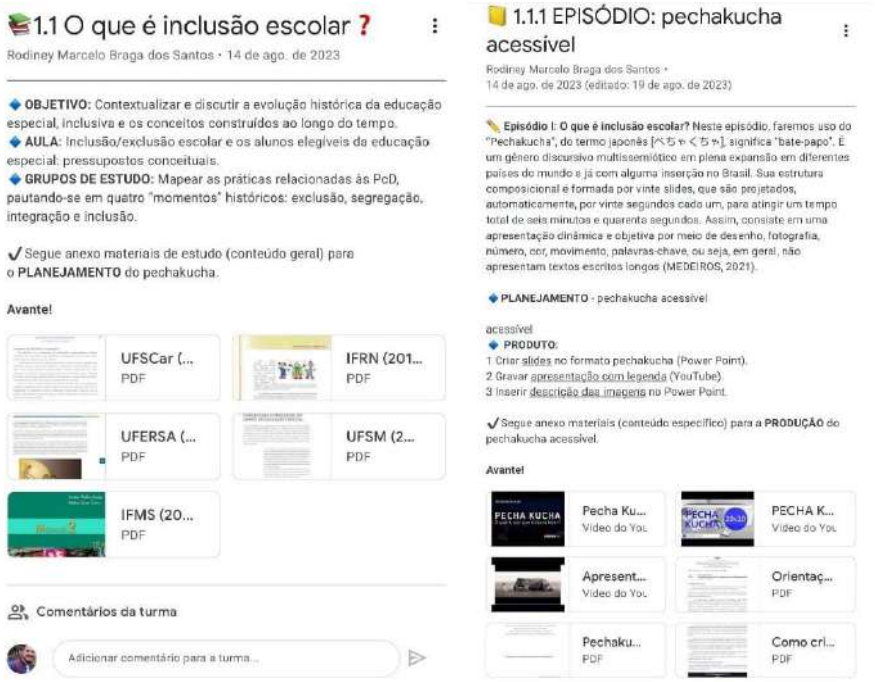
of instructional planning, the processes and products (accessible teaching materials) developed in the fourth and final formative episode aimed to present curricular accessibility proposals for inclusive mathematics teaching (Figure 7).

**Figure 4 – Episode I**






Source: Santos (2024, p. 87-88).


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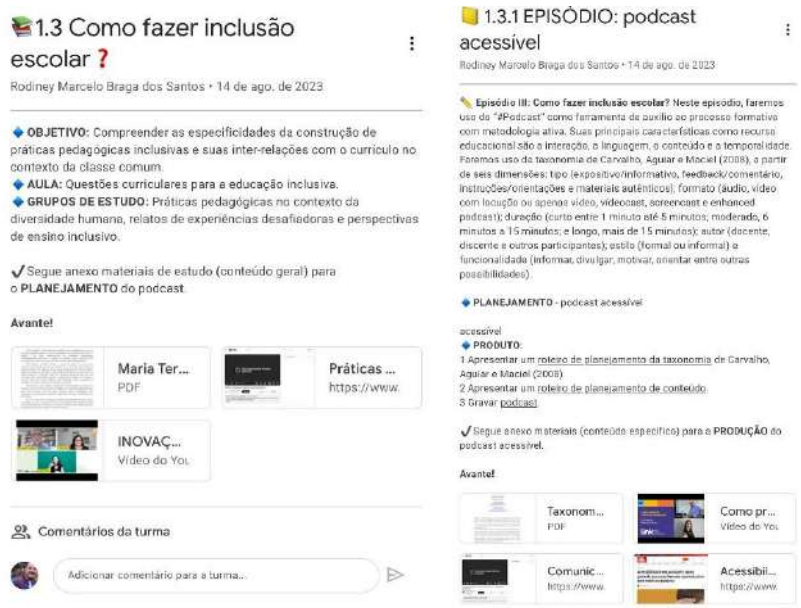
**Figure 5 – Episode II**


Source: Santos (2024, p. 90-91).

**Figure 6 – Episode III**




Source: Santos (2024, p. 93-94).

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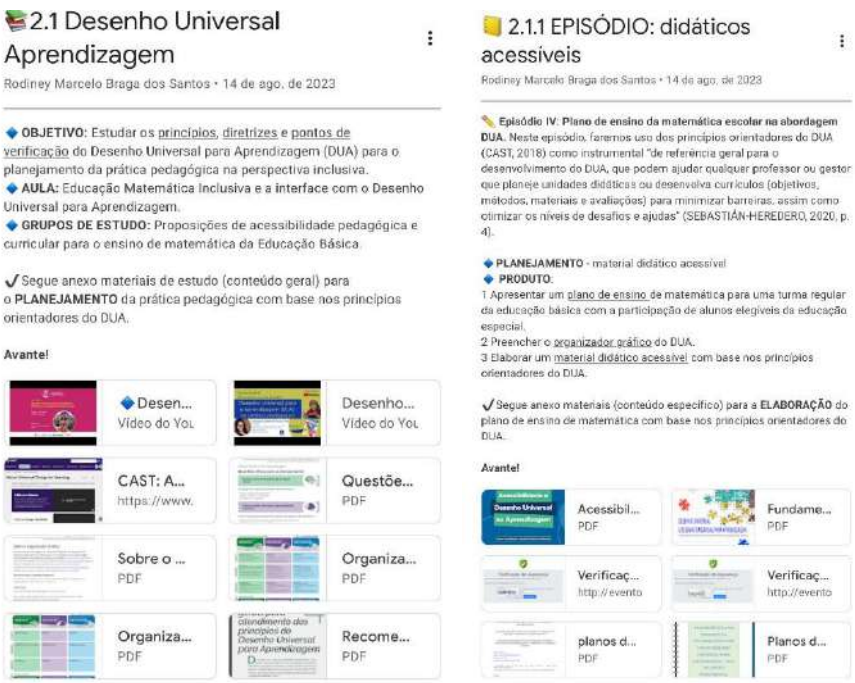
**Figure 7 – Episode IV**




Source: Santos (2024, p. 96-97).

It is worth highlighting that the Google Classroom web service was used as a resource to extend the in-person curricular activities. It served for recording guidance procedures (learning pathway scripts), consulting references for the production of accessible instructional and didactic materials (media library), and enabling asynchronous communication (discussion forums) as an instrument for dialogue and assessment. According to Pimentel (2006, p. 31), the forum is “a mechanism conducive to the development of debates [...] organized as a tree structure in which topics are hierarchically arranged, maintaining the relationship between the initial topic, responses, and counter-responses” (Pimentel, 2006, p. 31).

Additionally, we used Padlet, a new hypertext content organization model that “allows the creation of a shared environment where it is possible to associate text,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images, sounds, and other materials collaboratively" (Oliveira; Galvão; Souza, 2024, p. 16) to compose a virtual collection of artifacts developed in the formative episode.

Furthermore, as a self-assessment event, we proposed the writing of a "pedagogical letter," understood as a powerful instrument for memory, systematization of formative experiences, and reflection. Its purpose is to locate significant narratives that guide shared reflections. According to Paulo (2018), the pedagogical letter constitutes a writing modality and an innovative research tool capable of bringing the researcher closer to the research subject. Thus, participants were invited to write their pedagogical letters following this guideline: *Which information and/or knowledge studied during this formative path can you systematize in a Pedagogical Letter, in which you share your reflections with your peers? Let's go!*



### 3.5 Stage 5: Evaluation

According to Backes et al. (2011), qualitative research encompasses different methodological approaches, enabling a dynamic process of adopting new data collection and analysis procedures. Gatti (2004) states that there are educational demands whose: "contextualization and understanding need to be qualified through quantitative data [...] combining this type of data with data derived from qualitative methodologies can enrich the understanding of events, facts, and processes" (Gatti, 2004, p. 13).

In other words, these would not be identified and analyzed as thoroughly if not highlighted by tools characteristic of quantitative research.

Madureira, Galvão, and Schneider (2025, p. 47) corroborate this view by detailing the main evaluation instruments used in DSR research. For example, "to analyze data produced in this validation stage, the researcher can use both quantitative and qualitative strategies. As quantitative techniques, descriptive analysis techniques can be employed."

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Following the formative episodes that fostered constructions and reflections arising from dialogic spaces and problematizations carried out in the collaborative action research procedure, we present the three quantitative instruments used for data collection and analysis, namely: the New Index of Learning Styles; a Likert-scale questionnaire regarding prior and constructed knowledge in the pedagogical intervention; and the Likert Scale of Social Attitudes toward Inclusion, respectively.

Regarding the first instrument, Pereira and Vieira Júnior (2013, p. 185) argue that learning styles express their influence as a relevant element for better didactic planning. Thus, they provide teachers with methodological diversity in teaching, which may be potentially necessary in pedagogical practice. That is, “it is important to know these specific characteristics so that more precise and favorable interventions for learning can be carried out.”

Learning styles correspond to natural and individual behavioral patterns that indicate the ways in which each person tends to find it easier to learn. Among the various existing models, we adopted the one proposed by Felder and Silverman (1988), as well as the new version of the Index of Learning Styles (ILS) test by Felder and Soloman (1991), later revised by Vieira Júnior (2014), titled the New Index of Learning Styles (N-ILS).

The choice of this instrument is justified by the fact that the original model is one of the most widely disseminated in the international literature. For instance, it was the most referenced work by a journal over a ten-year period, has surpassed one million citations according to estimates, and the test has been translated into various languages (Vieira Júnior, 2014).

The learning styles model proposed by Felder and Silverman (1988) comprises four dimensions. Perception corresponds to the moment when the student is first introduced to new content; input, considered reception, is defined in the initial assimilation and modeling stages; processing corresponds to the phase when the student, more conscious and confident, conducts tests, analyses, and inferences; and understanding, especially regarding the classroom perspective, applies across the

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previous three stages. Each dimension has two poles, resulting in 16 different behavioral combinations.

To categorize respondents according to their singularities, Felder and Soloman (1991) developed the Index of Learning Styles (ILS) test, originally composed of 44 forced-choice questions, equally distributed among the four dimensions with 11 items each. Each question offers two alternatives, “a” and “b,” representing the opposite poles of each dimension. However, due to the instrument’s wide international dissemination, the ILS underwent several validation studies, many yielding insufficient results. In Brazil, although two studies attempted to validate the instrument, their results were divergent, showing that the test did not satisfactorily meet its proposed objectives. Given these limitations, related to both cultural and translation aspects and the inconsistency of specific items in the Brazilian versions, the New Index of Learning Styles (N-ILS), developed by Vieira Júnior (2014), was submitted to a validation process and recognized by Professor Felder himself.



Based on a questionnaire, participants in this study were asked to choose either option “a” or “b” to indicate their response to each question, with five questions per dimension (perception, input, processing, and understanding). The prevalence level of each learning style—classified as mild, moderate, or strong—was identified through a calculation that counted the number of “a” and “b” responses in each dimension. The higher value was subtracted from the lower, resulting in a score of 1a or 1b, 3a or 3b, 5a or 5b, as possible outcomes. These scores indicate the strength of preference: 1 for mild, 3 for moderate, and 5 for strong (Vieira Júnior, 2023).

The sample consisted of 28 students (35.7% female and 64.3% male). It was possible to analyze individual learning styles, revealing the percentage falling within each of the two poles of the four dimensions.

In the perception dimension, the students were predominantly sensing (78.6%), with the majority (45.4%) showing a moderate preference. Among intuitive learners, only 33.3% showed a strong preference and 16.7% a moderate preference. Therefore, in this dimension, it is important to consider that although intuitive students

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may favor conceptualizations and theories, their inclination toward this pole is generally mild, suggesting that behavioral characteristics associated with this style may also contribute to learning development. Thus, there is a greater likelihood of acquiring knowledge when students can see, touch, and hear. In this context, practical and laboratory classes can potentially enhance learning outcomes for these students (Vieira Júnior, 2012).



In the input dimension, 67.9% of students were visual learners, making it the dominant pole. A notable aspect of this dimension is that 47.4% of participants expressed a strong preference for the visual pole, whereas only 33.3% of verbal learners showed a strong preference. Additionally, 44.5% of verbal learners demonstrated a moderate preference for the verbal pole. Thus, the use of strategies that address both poles can significantly contribute to learning development, especially considering that the visual pole is predominant, while the verbal pole presents a range of preferences (strong, moderate, or low). Therefore, employing teaching strategies that integrate visual demonstrations and verbal explanations tends to promote more flexible and effective pedagogical actions (Vieira Júnior, 2012).

In the processing dimension, 64.3% of students were reflective learners, with half of them showing a mild preference. Among active learners, 40% exhibited a moderate preference. This suggests that while reflective learners prefer to think about the topics and situations presented to them, active learners understand better by participating. Hence, implementing teaching practices that simultaneously engage active learners and lead them toward reflection may be a personalized strategy for more effective learning (Vieira Júnior, 2012).

In the understanding dimension, most students were sequential learners (71.4%). Among global learners, 75% demonstrated a mild preference for the global pole, with none showing a moderate preference. This indicates that linear reasoning was predominant among participants, even among those classified as global learners. Therefore, the importance of pedagogical strategies that gradually build knowledge becomes evident (Vieira Júnior, 2012).

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However, it was found that within this group, there was no balance between the poles of the evaluated dimensions, with more than 60% of students in each dimension concentrating in the preferred pole. From the perspective of Universal Design for Learning (UDL), it is assumed that all individuals display, to some extent, a predisposition toward both poles of each dimension, with varying degrees of preference—mild, moderate, or strong. For learning to be effective, students must develop the ability to operate using both approaches. In this sense, identifying the learning styles of participants in this study was essential to guide the flexibility of formative actions.

As for the second instrument, within the educational context, the study of social attitudes becomes relevant to understanding the actions adopted by teachers based on their pedagogical knowledge in relation to student learning, as established in a collective environment. According to Souza, Pereira, and Lindolpho (2018, p. 116), “an individual in interaction with the environment forms impressions about others that influence their own self-perception, shaping and altering their own behavior” (Souza; Pereira; Lindolpho, 2018, p. 116).

Based on this formative proposal, the Social Attitudes Toward Inclusion Likert Scale (Escala Likert de Atitudes Sociais em relação à Inclusão – ELASI) was applied to participants. This instrument was developed by the Research Group on Difference, Deviation, and Stigma at the São Paulo State University (UNESP), Marília campus. Its purpose is to measure social attitudes toward inclusion, and it meets all the necessary criteria for standardization and reliability (Omote, 2005).

Shortly after its development, ELASI became widely used in research, both by members of the original research group and by scholars from different regions of Brazil. A significant portion of these studies has focused on describing and evaluating social attitudes toward inclusion. According to Omote (2018), “based on data from over 3,000 participants in various studies, ELASI was revised and reorganized, resulting in a second version (Omote, 2018, p. 27)

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The Likert-type scale consists of two equivalent forms, A and B, each containing 35 items—30 of which measure social attitudes toward inclusion, and five are lie scale items. Each of the 35 items includes five response options expressing degrees of agreement or disagreement with the statement: strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree. Half of the items are positively worded, meaning agreement indicates favorable social attitudes toward inclusion, while the other half are negatively worded, where agreement indicates unfavorable attitudes. The lie scale serves as an indicator of the reliability of the responses (Omote *et al.,* 2005).

This stage involved administering the test collectively to all participants during the final meeting of the semester's instructional activities. The researcher conducted the session in a supervised manner—being present to provide guidance and clarify doubts about how to complete the scale—without offering any information that might influence participants' answers.

To analyze the ELASI data, a social attitude score toward inclusion was calculated for each participant. The individual scores were determined according to the procedures established in the scale's standardization. Initially, the lie scale scores were calculated, after which the lie items were excluded.

The lie scale was scored as follows: if a participant's response matched the expected answer, a score of 0 was assigned; otherwise, the item received a score of 1. Thus, lie scale scores ranged from 0 to 5, with a score of 0 or close to 0 indicating high data reliability (Omote *et al.,* 2005). In this study, we observed that out of the 28 students who completed both forms, 24 scored zero, indicating that they understood the items and responded reliably. The remaining participants did not score above 1.

The remaining ELASI items were scored according to the selected response, based on the following criteria: for positively worded items, a score of 5 was assigned to "strongly agree," 4 to "somewhat agree," and so on, down to 1 for "strongly disagree." For negatively worded items, the scoring was inverted—"strongly disagree" received the maximum score of 5, while "strongly agree" received the minimum score of 1. The


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participant's total score was calculated by summing the values of all items, yielding a possible range from 30 to 150 (Omote *et al.,* 2005).

Based on the results, score fluctuations were observed in both positive and negative directions. Although the ELASI forms were designed to be statistically equivalent (Omote; Pereira Jr., 2011), social attitude scores toward inclusion measured using Form A were compared to those from Form B through the Mann–Whitney test. No statistically significant differences were found between them, as the p-value of 0.6937 remained above the significance level of 0.05 (95% confidence). The results obtained from the investigated sample indicated that the prospective Mathematics teachers expressed agreement with inclusion, showing a higher incidence of favorable attitudes, in line with the paradigm of inclusive education.



As for the third instrument, a Likert Scale was also used. This scale presents a set of statements related to the subject under analysis, and through a scale of agreement, participants indicate their degree of evaluation. The choice of a closed-ended questionnaire, in the Likert Scale format, aimed to encompass the plurality of perceptions among participants—thereby meeting the criteria for valuing respondents' subjectivity. In this case, the goal was to measure the perceptions of these preservice teachers regarding the processes and outcomes of the formative episodes developed. An online form was provided via Google Forms at the end of the curricular component. The categories analyzed were organized into three main blocks, represented in Figure 8.

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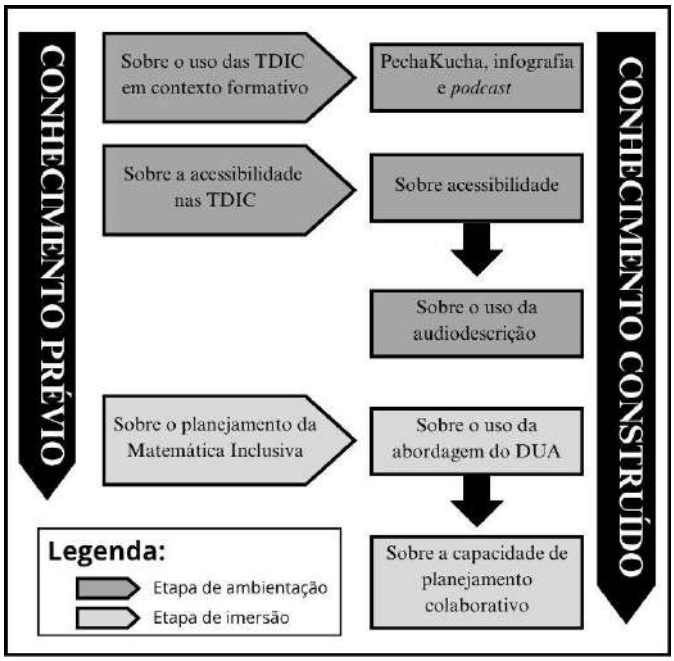
**Figure 8 – Likert Scale questionnaire on the pedagogical intervention**




Source: Santos (2024, p. 104).

For the development of this data collection instrument, the planning and production of accessible instructional and didactic materials created in each formative episode were considered as outcomes. The instrument consisted of 10 questions, each with four response options aimed at evaluating both the prior and the constructed knowledge of the participants throughout the formative process. The response options ranged from one (no knowledge) to four (excellent knowledge). In this study, the results will be presented graphically, based on the sum of the frequencies corresponding to each response option.

Figure 9 presents a chart describing the data regarding the participants' prior knowledge.

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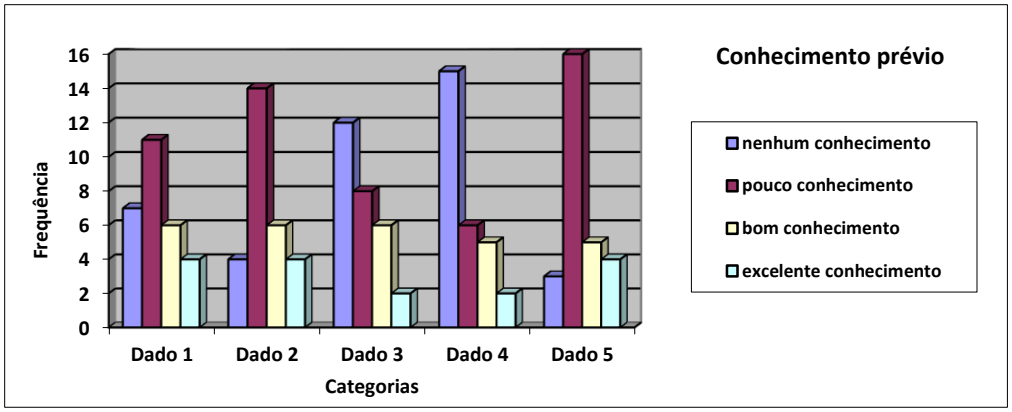
**Figure 9 – Data on participants' prior knowledge**




Source: Authors (2025).

The equivalent of 25% (7) of participants reported having no prior knowledge, while 39.3% (11) indicated limited knowledge regarding digital artifacts (PechaKucha, infographics, and podcasts). Among the preservice teachers, 14.3% (4) reported excellent knowledge, and 21.4% (6) reported good knowledge. It is worth noting that the curricular component Mathematics Applied to Mathematics Education in Inclusive Education is offered concurrently with the course New Educational Technologies Applied to Mathematics Teaching during the final semester of the program. Some students had already completed one or both courses, while others were currently enrolled, which broadened their repertoire concerning the use of educational technologies.

As for the mentioned artifacts, none of the participants were familiar with the PechaKucha format, while the other two had been experienced in different contexts: infographics, for example, had been created manually (in physical format), and podcasts had only been used for entertainment purposes, without educational intent. Thus, the data—showing that 64.3% (18) of participants had little to no knowledge—highlight the innovative nature of using these digital artifacts for pedagogical purposes. This finding is also supported by excerpts from participant reflections presented

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throughout this dissertation, some of which were used to illustrate, with fidelity, the implementation of each formative episode.

Furthermore, the instrument also assessed participants' prior knowledge regarding digital accessibility in school contexts. By incorporating digital accessibility, teachers provide conditions for reach, perception, understanding, and interaction for all students—aligned with the principles of Universal Design for Learning (UDL), which aims to maximize student potential and eliminate barriers in the teaching-learning process (Monteiro; Santos, 2024).



Results showed a similar pattern to the previous data: 64.3% (18) of participants indicated insufficient knowledge in this area, with 14.3% (4) reporting no knowledge and 50% (14) reporting limited knowledge. These results reinforce the importance of incorporating this topic into curricular components related to the study of digital technologies.

It is also important to note that the curricular component analyzed in this study is offered alongside the course Brazilian Sign Languages – Libras, whose syllabus includes "Assistive Technologies." Some students had already completed, and others were taking, courses related to this topic, which broadened their knowledge about assistive technology (AT) tools for deaf or hard-of-hearing individuals. Among these tools, applications such as VLibras, HandTalk, and others stood out and were meaningfully used by some groups during the immersion phase. This context was reflected in the following data: 14.3% (4) of the participants reported excellent knowledge, and 21.4% (6) reported good knowledge.

Another aspect investigated was participants' prior knowledge about Universal Design for Learning (UDL). This was explored throughout the entire formative process, justified by UDL's benefits, applicability, and strategies for promoting inclusive education. As Almeida and Moreira (2021, p. 4) point out, its application "[…] of pedagogical action and the expansion of learning opportunities for students with visual impairments and low vision [...] students with intellectual disabilities, dyslexia, attention deficit, and even students without disabilities" (Almeida e Moreira, 2021, p. 4).

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É It was found that 85% (20) of the preservice teachers lacked sufficient knowledge to develop an AD script in a school context. Among the remaining participants, 7.1% (2) reported excellent knowledge, and 21.4% (6) reported good knowledge. These findings may be explained by the conceptual confusion between audio description (AD) and basic descriptive narrative. According to Oliveira and Alves (2013, p. 2), AD: “has its own characteristics that grant it a distinct concept. Therefore, it cannot and should not be understood as a simple description, or an explanatory narrative of facts, or even a narrative exposition of what is seen” (Oliveira e Alves, 2013, p. 2).

According to Pearson (2015), the UDL approach stands out both conceptually and methodologically, as it enhances the training of preservice teachers in lesson planning guided by the principles of inclusion and adapted to students’ learning styles and needs. However, Mainardes and Casagrande (2022, p. 111) affirm that “although several recent publications address UDL, it is still underexplored in both preservice and in-service teacher education.”

In line with the data from this study, regarding prior knowledge of the UDL approach, the chart indicates that 53.6% (15) of the participants had no prior knowledge and 21.4% (6) had limited knowledge, totaling 84% (21) of the sample.

Concerning the planning of school mathematics from an inclusive perspective, the data confirm that this field is not treated as a transversal theme within the curriculum project, but rather as a subject addressed in a single curricular component. We understand this as necessary for enhancing disciplinary aspects of knowledge. To illustrate, 10.7% (3) of participants reported no knowledge and 57.1% (16) reported limited knowledge in this area, totaling 67.8% (19).

Figure 10 presents a second chart that displays the results related to the knowledge constructed by the preservice teachers through the implementation of the formative episodes, with emphasis on the “excellent” and “good” levels. It was found that 96.4% (27) of participants demonstrated knowledge regarding the use of digital

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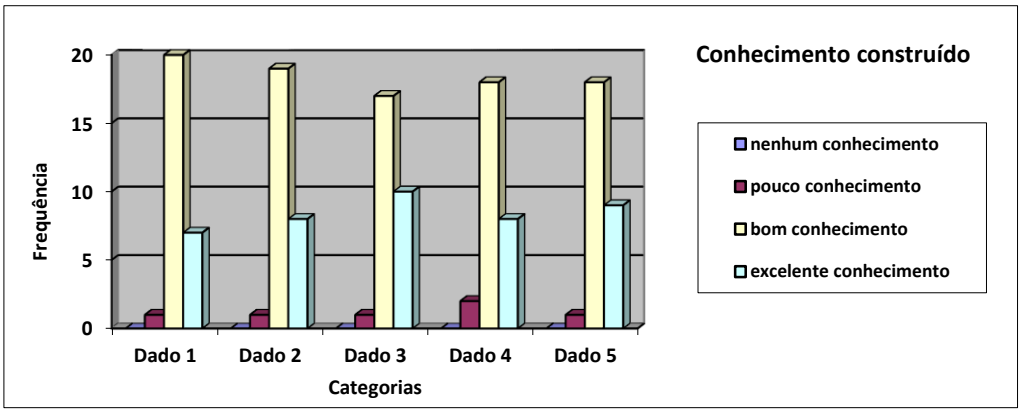
artifacts—PechaKucha, infographic, and podcast. Regarding digital accessibility, 97.4% (27) of participants reported having built significant knowledge of the topic. It was also observed that 92.9% (26) demonstrated mastery of accessibility tools aimed at deaf or hard-of-hearing individuals. It is worth noting that one of the students did not actively participate in the proposed activities, which may have influenced the final results.



**Figure 10 – Data on participants' constructed knowledge**




Source: Authors (2025).

As previously mentioned, the incorporation of UDL, technology, and various individual and collective learning strategies are essential areas of knowledge for basic education teachers (Pearson, 2015). However, based on the knowledge constructed by the participants in this study—preservice Mathematics teachers—they will be equipped for pedagogical action in inclusive school contexts through ongoing engagement and agency.

### 3.6 Step 6: deciding on the best solution

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We begin from the premise that numerous strategies have the potential to be implemented under each UDL principle, and that there is no predefined order that must be followed for their effective application.

The affective networks play a crucial role in welcoming, engaging, and providing emotional feedback in the learning process. They are essential for maintaining students' motivation, interest, and involvement. This directly impacts how learners experience education and their active participation in educational activities. This network is linked to the principle of engagement, which supports flexibility and the organization of various means to address the particularities of each student. In other words, it seeks to plan alternatives to embrace interests and identities, sustain effort and persistence, and strengthen emotional capacity.

The recognition networks act in the identification and clarification of information patterns and are essential for information assimilation, revealing how such information is processed. This network is connected to the principle of representation, suggesting pathways that may be directed to students so that they can access their prior knowledge and/or concepts and ideas through the information provided to construct an understanding of the subject being taught. In other words, it aims to plan alternatives for perception, language, and symbols, as well as the enhancement of knowledge.

The strategic networks play a critical role in managing learning, especially in how students validate their skills and demonstrate how their actions are directed toward specific objectives. This network is tied to the principle of action and expression, which emphasizes the learner’s autonomy in their educational process. This means planning alternatives for interaction, expression, communication, and the development of strategies.

Figure 11 presents a practical chart with some of the strategies implemented and analyzed in light of UDL Version 3.0 (Santos, 2024).

**Figure 11 – Teaching to include: mathematics education and its interface with UDL**

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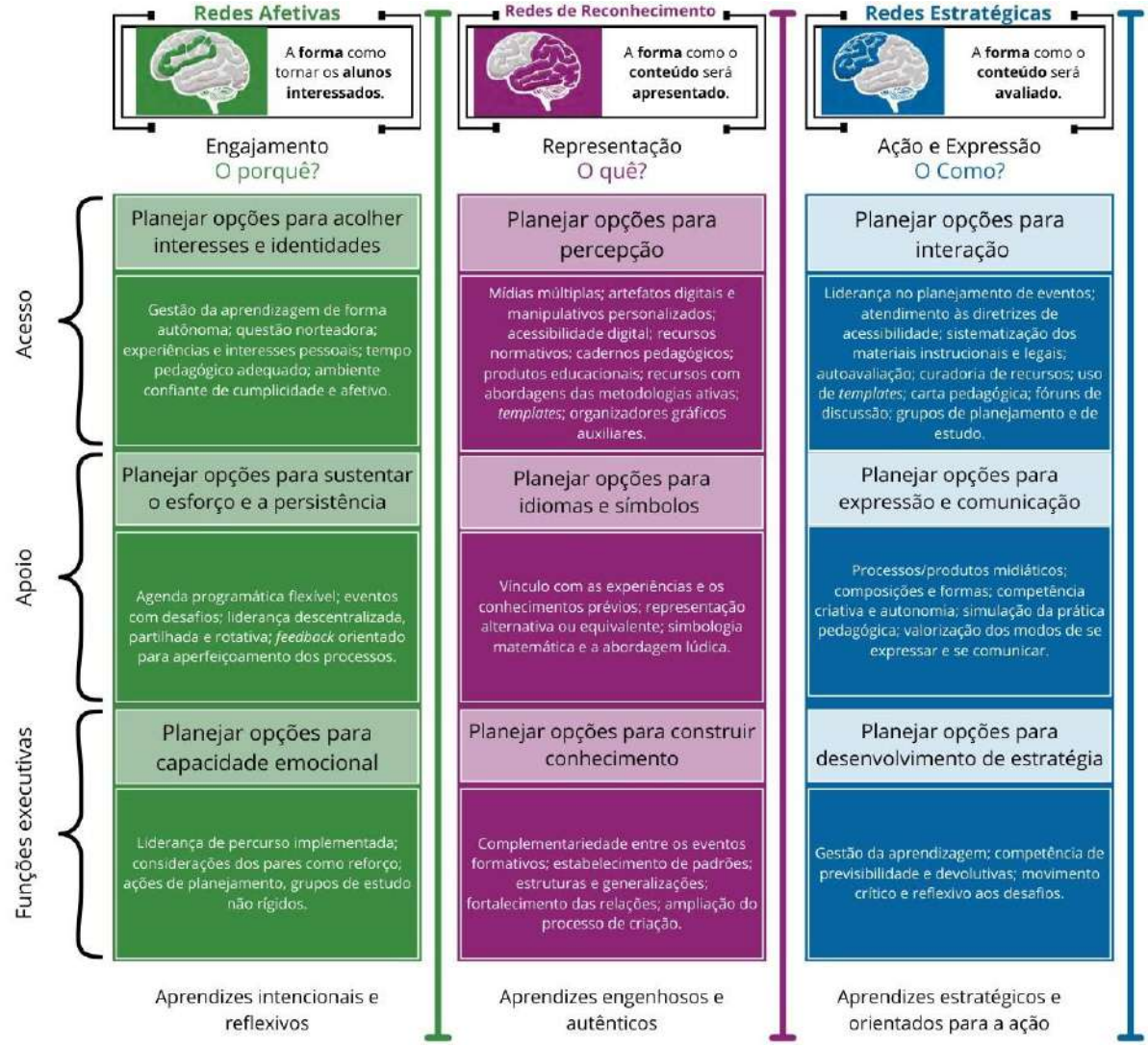


Source: Santos (2024, p. 150).

### 3.7 Step 7: reflection and learning

The formative design developed in this study holds social, political, and pedagogical significance. In the social dimension, this is evident when the humanistic perspective of these future teachers takes center stage in the face of challenges imposed by a society that still segregates in order to include—recognizing that

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education is “a place where all of society questions itself—it struggles and seeks itself” (Gadotti, 2004, p. 43). Education is essentially a political act (Saviani, 2012), implying an ongoing process of individual and collective transformation.

In this sense, the knowledge constructed becomes relevant when considering the conditions necessary to rethink the contemporary educational landscape, grounded in the historical context of how society and subjectivity are shaped. As such, it becomes a tool for transformation, aimed at the recognition and valuing of diversity in education. Pedagogically, the processes of familiarization and immersion contribute to the expansion of the participants’ didactic repertoire, strengthening the competencies necessary to promote inclusive educational practices.



In this collaborative action research, we start from the understanding that a teacher does not possess the power to alter Mathematics itself to make it more comprehensible, but can diversify the methods and approaches used in pedagogical practice within the classroom. Considering teacher education as a fundamental priority for promoting inclusive education—and focusing, in this study, both on the initial training space of Mathematics teachers and the practice of teaching as an instance of continuous professional development—collaborative action research guided by the UDL approach proved to be a repertoire geared toward innovation. In this regard, several characteristics highlight this innovative potential: the methodological tension between structure and action, the effective articulation between theory and practice, interdisciplinarity, and the encouragement of creativity.

Thus, planning—an element inherent to teaching and representative of pedagogical action—became central to the initial training of teachers, shaped by the principles of UDL. As a result, this formative initiative enhanced new forms of engagement and instructional options by providing a structured framework that supported differentiated instruction through clearly defined goals, materials, methods, and personalized assessments.

We assert that a formative process focused on flexibility and aligned with the students’ interests and needs is an intentional, situated, and well-grounded model. It

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allows for contextualizing and questioning pedagogical and didactic experiments regarding curriculum access, accessibility, and effective learning.

For instance, in this study, the implementation of UDL principles as a teacher education strategy contributed to the development of a group culture and collaboration within the “spaces” and “times” of learning management, aiming to improve teaching, learning, and assessment processes. Moreover, it provided a solid and meaningful pedagogical environment by making visible inclusive curricular changes, enabling a process of self-management in pedagogical practice, promoting fair learning practices, recognizing and valuing diversity, and reinforcing the advancement of an inclusive culture within schools.



However, we argue that encouraging inclusive training spaces fosters the creation of reflective processes that shift focus toward attentiveness to diverse learning needs, rather than relying on a traditional model of training centered on learning how to do. Furthermore, by incorporating the theoretical and methodological assumptions of UDL into teacher education, it becomes possible to enhance pedagogical attitudes with expanded dimensions—such as autonomy, critical thinking, and reflection—while also expanding appropriate opportunities to fully include all students in learning environments.

### 3.8 Step 8: communicating the results

With regard to the pedagogical booklet artifact (Figure 12), this material brings together the theoretical foundations and the pathway of the formative design applied to students in a Mathematics Teacher Education Program—that is, the formative episodes that give shape to some of the contributions of this arrangement. It aims to provide tools for proposals focused on teacher education, innovation, and curricular differentiation in Mathematics teaching, with implications from an inclusive perspective. The target audience of the material is Mathematics teachers in Basic Education, with

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the goal of offering resources for inclusive practices through an interactive format that guides them toward accessible educational, instructional, and informational materials.

**Figure 12 – Pedagogical Booklet (cover/table of contents)**




Source: Santos (2024, p. 174).

## 4 Final considerations

The development of the pedagogical booklet was grounded in the trajectory of constructions and reflections stemming from the issues identified throughout the collaborative action research process. The formative spaces guided by the planning based on Universal Design for Learning (UDL) represent a robust and meaningful pedagogical environment, as they allow for the envisioning of inclusive curricular transformations, the experience of self-managed pedagogical practice, the critical

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reflection on actions aimed at equitable learning, the recognition and appreciation of diversity, and the strengthening of a culture of school inclusion.

As a practical result of this study, the educational product Formative Episodes for Mathematics Education Guided by the Principles of Universal Design for Learning is presented as a tool for the design of training, innovation, and curricular differentiation proposals. In other words, it serves as a creative planning process for pedagogical practices based on UDL, whether for the education of mathematics teachers or for the planning of inclusive mathematics teaching.



Therefore, this educational product contributes to the expansion of knowledge on Mathematics Education from an inclusive perspective. Regarding its impact on the development of innovation, its relevance is highlighted in the improvement of pedagogical attitudes that are more autonomous, critical, and reflective. In the field of scientific development, its contribution lies in pedagogical and technological mediations aligned with the inclusive perspective and the Universal Design for Learning (UDL) approach. In terms of technological development, the potential of educational processes and products aimed at teacher education, with a focus on inclusion, is emphasized.

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