LUDIC-PEDAGOGICAL PRACTICES FOR TEACHING EARTH SCIENCES IN EARLY CHILDHOOD EDUCATION: INTEGRATING CURRICULAR GUIDELINES, UNIVERSAL DESIGN FOR LEARNING, AND GEOSCIENCE LITERACY PRINCIPLES

PRÁTICAS LÚDICO-PEDAGÓGICAS PARA O ENSINO DE CIÊNCIAS DA TERRA NA EDUCAÇÃO INFANTIL: INTEGRANDO DIRETRIZES CURRICULARES, DE DESENHO UNIVERSAL DE APRENDIZAGEM E DE ALFABETIZAÇÃO EM GEOCIÊNCIAS

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Resumo. Apesar do crescimento da produção técnico-científica da área da Educação em Ciências da Terra (ECT) no Brasil, a integração de conceitos geocientíficos às diretrizes curriculares nacionais permanece desafiadora, especialmente na Educação Infantil (EI), que requer atividades lúdico-pedagógicas e respeito ao desenvolvimento das crianças. Considerando esta demanda, apresenta-se resultados de uma pesquisa-ação que desenvolveu e avaliou uma sequência didática (SD) para ECT na EI. A SD incluiu atividades em sala de aula e ambientes externos, com três momentos principais: uma exposição interativa sobre as "Esferas Terrestres", uma atividade lúdica e experimental, e, duas brincadeiras educativas ao ar livre. Os critérios para avaliação das atividades foram os estímulos aos marcos do desenvolvimento, conceitos de ECT, campos de experiência e objetivo de aprendizagem da BNCC e princípios do Desenho Universal de Aprendizagem (DUA). A avaliação indicou que a SD possibilita a ECT de forma acessível e atraente para as crianças em perspectiva inclusiva. O estudo reafirma a importância da ECT na EI e a necessidade de práticas pedagógicas diversificadas e da integração dos princípios do DUA para uma educação (geo)científica desde os primeiros anos escolares. Espera-se que este trabalho sirva de referência para futuras iniciativas, contribuindo para o ensino de Ciências da Terra na educação básica brasileira, desde as primeiras etapas escolares.
Palavras-chave: Educação em Geociências; Formação Inicial de Professores; Ludicidade.

Abstract. Despite the growth of technical and scientific production in the field of earth science education (ESE) in Brazil, integrating geoscientific concepts into national curriculum guidelines remains a challenge—particularly in early childhood education (ECE), which requires playful-pedagogical activities and respect for children's developmental stages. In response to this need, this paper presents the results of an action research project that developed and evaluated a didactic sequence (DS) for ESE in ECE. The DS included both classroom and outdoor activities, structured into three main components: an interactive exhibition of the "Earth's Spheres;" a playful and hands-on experimental activity; and two outdoor educational games. The evaluation criteria considered developmental milestones, ESE concepts, experience fields and learning objectives from the Brazilian Common Core Curriculum (BNCC), as well as principles of universal design for learning (UDL). The evaluation indicated that the DS enables accessible and engaging ESE for children within an inclusive framework. This study reinforces the importance of introducing ESE in early childhood and highlights the need for diverse pedagogical practices and the integration of UDL principles to foster (geo)scientific education from the earliest stages of schooling. We hope this work will serve as a reference for future initiatives, contributing to earth science teaching in Brazilian basic education from its foundational years.
Keywords: Geoscience Education; Initial Teacher Training; Ludicity.

1. INTRODUCTION

In 2023, Brazil marked 50 years of initiatives and research at the interface of geosciences and education (Gonçalves & Conceição, 2023). The past two decades have witnessed significant growth in scientific and technical production, along with consolidation of the field of earth science education (ESE). This consolidation has occurred through the interplay of curriculum, teacher training, and teaching materials, aiming to identify opportunities for incorporating earth sciences (ES) into Brazilian basic education at all levels (Carneiro et al., 2018; Carneiro et al., 2004; Bacci, 2009, 2015; Bacci & Piranha, 2020; Compiani, 2005; Menegat, 2009; Piranha et al., 2024; Toledo, 2005; Toledo et al., 2005). However, analyses of the current Brazilian Common Core Curriculum (BNCC), the official guideline for the development of educational programs and documents (Brasil, 2018), have shown that geoscience concepts remain fragmented across curricular components (Ponte et al., 2023; Negreiros & Reis, 2024), as well as in state-level curricula derived from the BNCC (Cardoso, 2023; Ponte et al., 2020). Consequently, there is an urgent need for initiatives to foster geoscientific knowledge acquisition by society at large (Ernesto et al., 2018).

In particular, the institutionalized integration of ESE actions aligned with the current curricular guidelines for basic education remains a challenge in Brazil (Imbernon, 2021). Playful-pedagogical activities, especially in early childhood education (ECE), which legitimize and respect children's development, diversity, and learning rhythms, are an emerging demand in Brazilian ESE (Gonçalves et al., 2021; Imbernon, 2021; Melo et al., 2020; Teixeira et al., 2017).

Despite this demand, there is a scarcity of research into the teaching of natural sciences that explores playful approaches to geoscientific topics. Teachers often "do not feel confident enough to propose new ways (playful or otherwise) of mediating geoscientific content in the classroom" (Teixeira et al., 2017, p. 293). Specifically in ECE, "despite the potential of working with Earth Sciences for young children to explore the BNCC's fields of experience and to promote the necessary stimuli for development of this age group, few publications have addressed the teaching of Geosciences" (Gonçalves et al., 2021, p. 2).

Considering this gap, our aim here is to disseminate the innovative potential of combining different theoretical-methodological frameworks in the planning and development of inclusive educational practices for ESE in ECE. It was possible to identify didactic opportunities for ESE in ECE integrated into the national guidelines for basic education, as well as theoretical-methodological principles, as presented in the following sections.

2. THEORETICAL FRAMEWORK

The theoretical framework of this study encompasses: (1) the contextualization of ECE as a mandatory stage of Brazilian basic education; (2) the principles and concepts of universal design for learning (UDL) that underpin the development of inclusive activities; and (3) the development of guiding references and inclusive practices in ESE in Brazil, with a focus on ECE.

2.1 Early Childhood Education in Brazil

The Brazilian Constitution establishes that ECE must be guaranteed by the State for children up to five years of age (Brasil, 1988). This is the first stage of basic education (Brasil, 1996) and includes daycare (creche), covering children's development up to 3 years and 11 months; and preschool, lasting two years (Brasil, 2013).

In the context of Brazilian educational legislation, the National Curriculum Guidelines for Early Childhood Education (DCNEI) define children as

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> historical and rights-bearing subjects who, in their interactions, relationships and everyday practices, construct their personal and collective identity, play, imagine, fantasize, desire, learn, observe, experiment, narrate, question, and construct meanings about nature and society, producing culture (Brasil, 2009, p. 12, our translation).

The National General Curriculum Guidelines for Basic Education establish that the purpose of ECE is the holistic development of children in their physical, psychological, intellectual, and social dimensions (Brasil, 2013). In accordance with these assumptions, the guidelines emphasize the diversification of activities at this stage of basic education, with special attention to playfulness:

> Pedagogical practices that comprise the curricular proposal of early childhood education must have interactions and play as guiding principles, ensuring experiences that [...] foster knowledge of oneself and the world through expanded sensory, expressive, and bodily experiences, enabling broad movement, the expression of individuality, and respect for children's rhythms and desires (Brasil, 2013, p. 25, our translation).

Regarding curricular organization, the BNCC (Brasil, 2018), Brazil's current guideline for curriculum and educational program development, does not divide ECE into subjects or curricular components. ECE is structured around interactions and play, which must ensure essential learning encompassing behaviors, skills, knowledge, and experiences within five fields of experience: "The self, the other, and us"; "Body, gestures, and movements"; "Traces, sounds, colors, and shapes"; "Listening, speaking, thinking, and imagination"; and "Space, time, quantities, relationships, and transformations" (Brasil, 2018, p. 40, our translation). These fields include learning and development objectives that guarantee children's rights to live together, play, participate, explore, express themselves, and build self-awareness (Brasil, 2018).

To ensure that all children achieve these rights, educational projects should align curricular guidelines and pedagogical practices—including methodological choices, resources, spaces, and time—with the perspective of UDL (Gonçalves et al., 2021; Zerbato & Mendes, 2018). Adopting UDL is essential in ECE, where each child is at a distinct stage of cognitive, affective and motor development, so that activities can meet the needs of all children, regardless of their particularities, whether due to developmental stage or physical/physiological disabilities (Gonçalves et al., 2021, p. 8).

2.2 Universal Design for Learning

The concept of universal design for learning (UDL) emerged in 1999, developed by the Center for Applied Special Technology (CAST) in the United States (Sebastián-Heredero, 2020; Zerbato & Mendes, 2018). Inspired by the universal design movement in architecture, which seeks to create accessible spaces for all people regardless of their abilities or limitations (Oliveira et al., 2019), UDL was adapted to education with the goal of ensuring that curricula and teaching methods are inclusive and accessible to all students (Pioker-Hara et al., 2024; Sebastián-Heredero, 2020). The central aim of UDL is to eliminate barriers to learning and to provide multiple means of engagement, representation and expression (Meyer et al., 2014).

UDL guidelines are not a fixed recipe, but rather a set of strategies that can be employed to overcome the barriers present in most existing curricula (Sebastián-Heredero, 2020). They offer a framework for developing options and the flexibility needed to expand learning opportunities (Sebastián-Heredero, 2020).

Conceptually, UDL draws from neuroscience, which highlights the diversity of the brain's learning networks and emphasizes the need for flexible and personalized approaches to teaching (Bettio et al., 2021; Oliveira et al., 2019; Sebastián-Heredero, 2020). UDL is structured around three core principles (Table 1): (1) Provide multiple means of representation, recognizing that learners differ in how they perceive and process information; (2) Provide multiple means of action and expression, enabling learners to demonstrate what they know in different ways; and (3) Provide multiple means of engagement, acknowledging that learners vary in their motivation and involvement with content (Meyer et al., 2014).

Table 1. Principles of UDL.

Principle	Multiple Means of Engagement	Multiple Means of Representation	Multiple Means of Action and Expression
Networks	Affective networks: the *why* of learning	Recognition networks: the *what* of learning	Strategic networks: the *how* of learning
Access	Provide options for: capturing interest (optimize individual choice and autonomy; optimize relevance, value, and authenticity; minimize threats and distractions).	Provide options for: perception (customize the display of information; offer alternatives for auditory information; offer alternatives for visual information).	Provide options for: physical action (vary methods of response and navigation; optimize access to tools and assistive technologies).
Development	Provide options for: sustaining effort and persistence (increase relevance of goals and objectives; vary demands and resources to optimize challenges; foster collaboration and community action; enhance mastery-oriented feedback).	Provide options for: language and symbols (clarify vocabulary and symbols; clarify syntax and structure; support decoding of text, mathematical notation and symbols; promote cross-linguistic understanding; illustrate through multiple media).	Provide options for: expression and communication (use multiple media for communication; employ varied tools for construction and composition; develop fluencies with appropriate levels of support for practice and performance).
Empowerment	Provide options for: self-regulation (promote expectations and beliefs that enhance motivation; facilitate personal coping strategies and skills; develop self-assessment and reflection).	Provide options for: comprehension (activate or supply background knowledge; highlight patterns, critical features, big ideas, and relationships; guide information processing and visualization; maximize transfer and generalization).	Provide options for: executive functions (guide appropriate goal-setting; support planning and strategy development; facilitate management of information and resources; enhance capacity for monitoring progress).
Goal	Expert learners: purposeful and motivated.	Expert learners: resourceful and knowledgeable.	Expert learners: strategic and goal-directed.

Source: Adapted by the authors from CAST (2018).

These principles were adapted to inclusive teaching in ECE by Bettio, Miranda & Schmidt (2021), as follows:

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a) Engagement – relates to the purpose of the content to be taught, or the why of learning a given topic. Educators should employ different resources to motivate and stimulate interest all students.
b) Representation – concerns the actual content to be presented, that is, the what of learning. This involves providing different means of comprehension. Information and instructions are presented in diverse ways so that all children can understand.
c) Action and Expression – relates to the how learners demonstrate what they have learned. Multiple options are provided for carrying out a given assessment, allowing children to express their acquired knowledge in different forms.

In the context of ECE, while UDL is especially relevant to ensure that all children—regardless of their abilities or backgrounds—have equitable access to learning opportunities, its application remains limited (Bettio et al., 2021; Silva-Junior & Dantas, 2022). Implementing UDL in ECE requires the design of activities that are both accessible and stimulating, using diverse materials and varying the forms of content presentation and children's modes of expression (Bettio et al., 2021).

2.3 Earth Science Education in Brazil

Worldwide research in ESE has resulted in the development of parameters for earth science literacy (Pedrinaci et al., 2013; Wysession et al., 2010) and curricular proposals for integration into formal basic education (King, 2015). While each of these publications has particularities, it is possible to identify 13 core concepts necessary for earth science literacy (Ponte & Piranha, 2020), which demonstrate both complementarity and correlation among the works: 1) Earth as a dynamic, open system of interacting components in constant transformation; 2) The study, teaching, and research of the Earth's system; 3) Geological time; 4) The origin of the universe, the solar system, and Earth; 5) Earth as a member of the solar system; 6) Earth's structured/layers; 7) Geosphere; 8) Hydrosphere; 9) Atmosphere; 10) Biosphere; 11) Environmental risks and natural hazards; 12) Human use of natural resources; and 13) Anthropogenic impacts.

In Brazil, the institutionalized integration of ESE initiatives into the BNCC remains a challenge (Imbernon, 2021). Recent studies have indicated multiple entry points for ESE in the BNCC, whether in the early and later years of elementary school or in high school (Ponte et al., 2023) or ECE (Gonçalves et al., 2021).

The relevance of ESE in ECE is also reinforced by Article 9 of the DCNEI, which states that pedagogical practices must: "encourage children's curiosity, exploration, wonder, questioning, inquiry, and knowledge of the physical and social world, of time, and of nature" and "promote interaction, care, preservation, and knowledge of biodiversity and sustainability of life on Earth, as well as avoiding the wasting of natural resources" (Brasil, 2009, p. 26, our translation).

The objectives of ESE at this stage of basic education include fostering psychomotor stimulation and development, while also encouraging children's awareness of geological/abiotic diversity and its role in sustaining life (Casimiro, 2013; Gonçalves et al., 2021; Melo et al., 2020). Developing ESE in ECE requires emphasizing experiences and playfulness that support knowledge construction in a clear, calm, and meaningful way (Gonçalves et al., 2019). These activities must legitimize and respect children's development, diversity, and learning rhythms (Pioker-Hara et al., 2024). Finally, while teaching activities in ESE at the ECE level must align with the current curricular guidelines—which do not always converge with UDL—they should nonetheless incorporate inclusive guidelines. Thus, pedagogical practices in ESE for ECE must consider UDL principles (Gonçalves et al., 2021; Pioker-Hara et al., 2024).

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3. METHODOLOGY

This is a qualitative, intervention-based study (Teixeira & Megid-Neto, 2017), inspired by the methodological principles of action research as outlined by Latorre (2005). The initial stage consisted of observation and direct experience of a teacher-researcher within an ECE school community. Although inspired by action research, the study cannot be fully characterized as such, since the intervention lacked participatory evaluation and collective reflection on changes in actions and educational practices after its implementation, nor was it possible to carry out multiple cycles of reflection–action.

This stage culminated in identifying a demand for pedagogical practices related to the school calendar of commemorative dates within the municipal school network, which included, among others, the celebration of Environment Day. Considering that in 2022 the United Nations celebrated World Environment Day with the theme “Only One Earth”, we decided to develop activities related to the Earth.

Subsequently, we studied theoretical references in ESE and ECE to design an intervention proposal, which was presented to the school administration and to eight ECE teachers during collective work and pedagogical planning time. At this point, the relevance of UDL for planning the activities was recognized. After adjustments based on feedback, a pedagogical intervention with the children was carried out, respecting ECE routines and schedules. The preparation of the teaching materials was didactically adapted from Grotzinger and Jordan (2013).

The research resulted in a pedagogical product—a didactic sequence—which was evaluated in light of the study’s theoretical references, namely: guidelines for ECE in Brazil, UDL, ESE, and geoscience literacy. To systematize the potential of the didactic sequence for ESE in ECE, we adapted the method of Gonçalves, Grama, and Passos (2021), which allowed us to describe the activities according to: cognitive/motor stimuli; geoscience concepts; BNCC fields of experience; BNCC learning objectives; required materials; methodology for implementation; and correlation with UDL principles.

The methodological adaptation consisted of three modifications: (1) cognitive/motor stimuli for child development were used instead of developmental milestones, according to the list presented by Gonçalves et al. (2021); (2) the item “geoscience concepts” was expanded to include the key concepts proposed by Ponte and Piranha (2020), highlighting their contribution to earth science literacy; and (3) the UDL guidelines developed and disseminated by CAST (2018).

4. RESULTS

The didactic sequence was entitled “Getting to know the planet we live on” and encompassed strategies and teaching resources organized both in the classroom and in outdoor environments. Its total duration was two hours, divided into three parts: (1) an interactive and dialogic exhibition in a themed classroom on the “Earth’s Spheres”; (2) a playful and experimental activity, “Waking up Volcanoes”; and (3) two educational games conducted outdoors.

4.1. Themed Classroom “Earth’s Spheres”

The themed classroom was designed to teach about the components of planet Earth, organized into earth spheres, including samples of rocks, minerals, soils, and representational didactic models (Figure 1). The classroom integrated five stations: geosphere, pedosphere, hydrosphere, atmosphere, and a playful-experimental activity station.

Figure 1. Themed Earth's Spheres classroom. a) General view of the classroom collection, integrating samples, models, and printed illustrations. b) Record of the initial discussion. c) Rock samples used to explain the geosphere. d) Representational model of a soil profile. e) Balloons representing the main gases of the atmosphere. f) Helium balloons used in the activity. g) Children inflating balloons. h) Materials used to explain the physical states of water. i) Fresh and dried fruits used in the activity on water in living beings.
Source: prepared by the authors.

Table 1 synthesizes the activities of the themed classroom, and subsequently describes the materials and method used to teach each earth sphere. Correlations with the UDL principles listed in the table are also detailed. We observed that in all five stations of the themed classroom, children can learn and develop in the BNCC experience fields "Traces, sounds, colors and shapes" and "Spaces, times, quantities, relations and transformations" (Brasil, 2018, p. 54), without variation among them.

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Table 1. Summary of activities in the themed classroom "Earth's Spheres" and their correlations with the theoretical-methodological frameworks assumed in the study.

Station	Objective	CDS	ESL	EF-BNCC	LO BNCC	UDL
Geosphere	Understand Earth's crust components and differentiate rocks and sediments	Talk about "yesterday, today, tomorrow"; Count and name objects; Provide materials of different sizes to play with; Use imagination and explain how things work	Minerals; Natural cycles; Rock types; Sediments	Earth as a dynamic and open system of interactive components in constant transformation; Geological time; Geosphere; Human use of natural resources	EI03ET01; EI03ET02; EI03ET05	Handling samples for tactile perception; Use of images as visual support; Demonstrative experiment to illustrate properties
Pedosphere	Recognize soil formation and constitution and its relation to rocks	Talk about "yesterday, today, tomorrow"; Name objects; Use imagination and explain how things work	Minerals; Vegetation; Natural cycles; Sediments	Earth as a system; Earth's structure/layers; Geosphere; Human use of natural resources	EI03ET01; EI03ET02	Initial dynamic to foster communication and interest; Experiment showing air in soil; Use of everyday materials to connect with reality
Atmosphere	Explain air composition, gas proportions, and their characteristics	Count and name objects; Play with objects of different sizes; Free play; Use imagination and explain how things work	Climate; Air masses; Weather; Rainfall	Earth as a system; Atmosphere	EI03ET01; EI03ET02; EI03ET05; EI03ET08	Balloons of different sizes/heights to illustrate gases; Writing on balloons for visual support; Each child inflating a balloon (expression and motivation)
Hydrosphere	Recognize physical states of water and their occurrence in nature and daily life	Count and name objects; Use imagination and explain how things work	Natural cycles; Weather; Rainfall	Earth as a system; Hydrosphere; Biosphere; Human use of natural resources	EI03ET01; EI03ET02; EI03ET05; EI03ET07	Use of objects, images, verbalizations, and infographics diversifying means of information; Fresh and dried fruits for tactile perception; Complementary graphic representation
Playful and experimental activity (Volcano)	Understand volcanism and eruption processes through an experimental model	Talk; Tell stories; Talk about "yesterday, today, tomorrow"; Use	Volcanism; Igneous rocks; Metamorphic rocks	Earth as a system; Earth studies; Geological time; Earth's structure/layers; Geosphere;	EI03ET02; EI03ET03; EI03TS02	Building clay volcanoes (creative expression); Use of illustrations for visual support; Collective shout

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	imagination and explain how things work	Natural hazards and disasters	“wake up volcano” for engagement

Source: Prepared by the authors. CDS = Child Development Stimuli; ESL = Earth Science Literacy; EF = BNCC Experience Fields; LO = BNCC Learning Objectives; UDL = Universal Design for Learning. EI03ET01 = Establish relations of comparison between objects, observing their properties; EI03ET02 = Observe and describe changes in different materials resulting from natural and artificial phenomena; EI03ET03 = Identify and select sources of information to answer questions about nature, its phenomena and conservation; EI03ET05 = Classify objects and figures according to similarities and differences; EI03ET07 = Relate numbers to their respective quantities and identify before, after, and between in a sequence; EI03ET08 = Express measures (weight, height, etc.) by constructing basic graphs; EI03TS02 = Freely express through drawing, painting, collage, folding, and sculpture, creating 2D and 3D productions.

4.1.1. Geosphere

This station included rock and sediment samples (Figure 1c). The rock samples used were basalt from the Serra Geral Formation, sandstone from the Bauru Group, and migmatite from the Amparo Complex, together representing the mineral diversity of the state where the study was carried out. For replication, educators can use any available samples, proceeding with primary classification (sedimentary, igneous, and metamorphic).Sediment samples included gravel (crushed stone), coarse sand, and fine sand, all of which are materials commonly used in construction. The activity method involved explanation using the samples and a demonstration of water infiltration in rocks.

The activity began with a discussion of geological elements in everyday life, such as construction materials. Next, we explained that these materials are extracted from rocks, which constitute the outermost layer of Earth, known as the crust. Then, the three types of rock samples were presented, drawing attention to the macroscopic features that best enable children to differentiate them—mainly colors and textures.

For the sedimentary rock, children handled the sample, observing the granular texture and visible grains that compose sandstone. For the igneous rock, attention was drawn to density (much denser than sedimentary rocks) and its dark color. In the case of granites, teachers can highlight the presence of visible crystals. For the metamorphic rock, attention was given to foliation, pointing out parallel bands of different colors with a deformed appearance (“looking like stretched modeling clay”) and folds, accompanied by explanation that these forms result from high temperatures and pressures. A demonstration of porosity was also conducted: using a pipette, drops of water were placed on the samples, showing infiltration into the sedimentary rock but not into basalt or migmatite.

Regarding UDL principles, handling the samples allowed tactile recognition of rock textures, providing alternatives to verbal information; printed illustrations supported visual relations; and a demonstrative experiment offered differentiated perception of rock types and their properties.

4.1.2. Pedosphere

The materials required for this station included two transparent containers, rock fragments, soil (collected from the schoolyard), plant samples with roots and leaves, and water. To begin the activity, the teacher asked children to imagine and say “What is beneath your feet?” The most common responses were “the floor” and “the earth.” We then explained that beneath the floor lies a soil layer, similar to that in the garden. The formation of soil was presented as a long process resulting from the action of rain, rivers, and wind, and that soil is a living system

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composed of minerals, air, water, and living organisms. To illustrate, a model of a soil profile was used (Figure 1d).

Rock fragments placed at the bottom of a transparent container represented the bedrock, while disaggregated pieces represented horizon C. These were covered with schoolyard soil, representing horizon A, and topped with leaves and roots representing horizon O. To evidence the presence of air in the soil, one container was filled with clean water, and soil clods were placed into it. Air bubbles immediately appeared, revealing air within the soil.

In relation to UDL principles, asking children to imagine and explain what was under their feet encouraged communication and engagement. The experiment visually demonstrated the presence of air in soil (air bubbles leaving the clods when placed in water), providing multiple means of perception and comprehension. The use of local soil as material reinforced connections with the children's everyday context.

4.1.3. Atmosphere

For this activity, one helium balloon and several uninflated party balloons were required. To explain that air is a mixture of gases with different properties, helium balloons and party balloons filled with exhaled air by each child were used. When asked what air consists of, responses included "air" and "oxygen." We explained that the air we breathe is rich in oxygen but is in fact a mixture of gases. Connections were made with the gaseous state of water discussed in the hydrosphere activity.

We emphasized that nitrogen, not oxygen, is the most abundant atmospheric gas. To represent proportions, three balloons were labeled: "N" (nitrogen), "O" (oxygen), and "other gases" (Figure 1e). Balloons were inflated in different sizes to represent their proportions, with the "N" balloon largest, the "O" balloon medium-sized, and "other gases" the smallest. To show the behavior of gases, helium balloons (Figure 1f) and party balloons filled by the children (Figure 1g) were simultaneously released: helium balloons floated to the ceiling while party balloons fell to the floor. The dynamics highlighted differences among gases.

From a child development perspective, this activity encouraged naming objects (gases), comparing quantities, free play, and imaginative explanations.

Regarding UDL principles, the balloons illustrated atmospheric composition—different sizes represented relative concentrations, positioned at different heights. Balloon volume provided an alternative to visual information, requiring mediation to explain gas representation. Labeling the balloons with percentages and gas names offered additional expression and communication resources. Finally, giving each child a balloon fostered autonomy, motivation and engagement.

4.1.4. Hydrosphere

The materials included: a bottle of mineral water, ice cubes, fresh and dried fruits, printed images of water bodies (river, beach, lagoon, glacier, Guarani Aquifer), and everyday water-related items (ice cube molds, a kettle with steam, and a glass of water). The activity aimed to demonstrate the different physical states of water and their occurrence in nature and daily life. The liquid state was introduced first, using bottled water and images of rivers, lagoons, and aquifers, showing fresh and salt water, stagnant and flowing water, and surface and groundwater (Figure 1a).

Next, an illustration of a kettle emitting steam was shown, and the children were asked what was happening. Common responses were that the water was "hot" or "on the stove." This was used to explain that when water is heated, it changes from liquid to gas (steam/ water vapor). Everyday examples included evaporation of puddles and drying of clothes in the sun, emphasizing evaporation as a natural phenomenon essential to understanding the water cycle.

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Children were then asked what happens when water is placed in a freezer, linking it to sub-zero temperatures. We explained that ice is the solid state of water, which unlike liquid or vapor, can be shaped and held. An ice cube was held between fingers to highlight this difference.

A potted plant, previously watered and covered with plastic wrap, was also shown, evidencing transpiration and condensation (Figure 1h). To demonstrate water in living beings, fresh and dehydrated fruits (grapes and plums) were compared, showing volume reduction due to water loss (Figure 1i). An infographic of water content in different fruits complemented this.

Regarding UDL principles, multiple representations (objects, images, verbal examples, and infographics) diversified information presentation. Tactile comparison of fresh and dried fruits offered alternatives to visual input, while graphical representations reinforced comprehension.

4.1.5. Playful and experimental activity

The materials used were vinegar, baking soda, food coloring, and detergent. Clay, leaves, and soil from the schoolyard were used to construct volcano models. Days beforehand, children had built two volcanoes with clay and PET bottles, guided by teachers.

The activity began by explaining magma as the material forming Earth's mantle, below rocks. The dynamic "what is beneath your feet" was revisited, using the soil profile model from the pedosphere section. Magma was explained as cooling and solidifying into magmatic rocks. Basalt, present in the collection, was cited as an example, formed by lava flows. The process of solidification was compared to water freezing into ice. We clarified that when magma emerges through a volcanic edifice it is called lava, and the process is called eruption. Children were told that volcanoes may remain "asleep" for long periods. To engage them, they were asked to chant together "wake up, volcano!" before the experiment.

The eruption was simulated by using baking soda, vinegar, detergent, and food coloring (Figure 2). The chemical reaction produced gas, causing the mixture to rise and flow slowly. Coloring gave it a reddish appearance.

Figure 2. Playful-experimental activity "Waking Up Volcanoes"
Source: prepared by the authors.

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In relation to UDL principles, constructing volcano models encouraged creativity and choice. Printed illustrations supported communication and comprehension, while the collective chant "wake up, volcano" fostered anticipation and motivation.

4.2.Playful educational activities in outdoor environments

After the experimental activity, the video "The Water Cycle for Children" (Smile and Learn, 2020) was shown. Two playful educational games were then carried out in the schoolyard: "Like a Little Drop of Water" in the playground and "Fossil Hunt" in the sandbox. Table 2 summarizes these outdoor activities, followed by detailed descriptions of the materials and method used for each. Correlations with UDL principles are also presented. We identified that both activities enabled children to learn and develop within the experience fields "Body, gestures and movements," "Traces, sounds, colors and shapes," and "Spaces, times, quantities, relations and transformations."

Table 2. Summary of playful educational activities in outdoor environments and their correlations with the theoretical-methodological references adopted in the study.

Educational Game	Objective	CDS	ESE	BNCC EF	BNCC LO	UDL
Like a Drop of Water	Experience water cycle processes in a playful way	Pretend play; Exploring environments; Imagining; Socializing; Naming objects; Diverse forms of play; Climbing stairs; Role-playing situations	Natural cycles; Air masses; Weather; Rainfall	Earth as a system; Earth in the Solar System; Hydrosphere; Atmosphere	EI03CG01; EI03ET02; EI03ET03; EI03ET07	Use of props (cards, TNT, EVA foam) to simulate environments; visual and tactile alternatives; plastic bag model as an option for children unable to climb
Fossil Hunt	Explore the concept of fossils and geological time through a simulated activity	Exploring environments; Talking about "yesterday, today, tomorrow"; Free play; Imagining; Motor coordination with shovels and brushes; Role-playing situations	Geological time; Sedimentary rocks; Fossils; Mass extinction	Earth system studies and research; Geological time; Geosphere; Biosphere	EI03CG01; EI03ET01	Individual excavation kits (supporting self-regulation and safety); Replica fossil as tactile resource; Free exploration of outdoor space

Source: Prepared by the authors. CDS = Child Development Stimuli; ESL = Earth Science Literacy; EF = BNCC Experience Fields; LO = BNCC Learning Objectives; UDL = Universal Design for Learning. EI03CG01 = Create with the body diverse forms of expression of feelings, sensations, and emotions, in daily life as well as in play, dance, theater, music; EI03ET01 = Establish relations of comparison between objects, observing their properties; EI03ET02 = Observe and describe changes in different materials resulting from natural and artificial phenomena; EI03ET03 = Identify and select sources of information to answer questions about nature, its phenomena, and conservation; EI03ET07 = Relate numbers to their respective quantities and identify before, after, and between in a sequence.

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4.2.1. Like a Little Drop of Water

Materials required: blue TNT fabric (or EVA mats), two placards with the words “liquid state” and “gaseous state” along with everyday images of these states (Figure 3b); white EVA cut in the shape of clouds; a transparent plastic bag with water; and a waterproof marker.

Methodology: a circuit was built on the school playground with TNT and EVA (Figure 3a). Children engaged in role-playing, imagining themselves as water drops moving through environments of the water cycle and undergoing physical transformations.

The activity began with each child holding the “liquid state” placard and walking one at a time over the TNT fabric, which represented a river (Figure 3c). At the foot of the stairs, they exchanged it for the “gaseous state” placard, climbed the stairs, and crossed the playground toward the slide, simulating evaporation (Figure 3d). The slide, embellished with EVA clouds, represented condensation. At this point, the children changed the placard back to “liquid state” and slid down, simulating precipitation as rain falling into rivers (Figure 3e). After finishing, each child returned to the line for the next child’s turn.

To provide an alternative illustration, a transparent plastic bag filled with water was placed at eye level in sunlight (Figure 3f). Water evaporated and condensed inside, forming droplets, reinforcing the processes of evaporation, condensation and precipitation previously shown in the video and the role playing.

Child development stimuli included: role playing, exploring natural environments, using imagination, socialization and use of pronouns (“I,” “we,” “you,” “he”, “she”), demonstrating affection, counting and naming objects, playing with objects of different sizes, running in varied ways in different spaces, climbing stairs and imagining situations.

Figure 3. Educational game “Like a Little Drop of Water**.** a) Playground embellished for role playing. b) Signs used. c) Initial stage: water in the river. d) Intermediate stage: evaporation. e) Final stage: precipitation. f) Bag model of evaporation/condensation.
Source: prepared by the authors.

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With regard to the correlation with UDL principles, the use of the liquid- and gaseous-state boards at different moments, along with the stylization of the playground using EVA and TNT to simulate a river and clouds, was intended to provide an option for information processing and the visualization of phenomena analogous to the role the child was performing in the pretend play. It also served as an alternative to auditory information. A model (a plastic bag with water and a drawing) was hung to provide an option for students who were not able to climb the stairs to go down the playground slide. Instead, they completed the path on the blue TNT and passed "under the bridge" while observing the model. The model also represented an alternative to provide options for perception (personalizing the presentation of information), for the use of language (illustrating), and for comprehension (guiding information processing and the visualization of the role the student was interpreting). We decided that only one child would perform the course at a time in order to respect self-regulation in the designed path, minimizing insecurity and the anxiety that another peer could cause if the course were performed simultaneously.

4.2.2. Fossil Hunt

The last activity of the didactic sequence consisted of a game in the schoolyard sandbox that once again engaged the children in pretend play, this time as paleontologists in search of a fossil. To carry out this activity, a representational model or fossil replica and flat, long-bristled brushes were required.

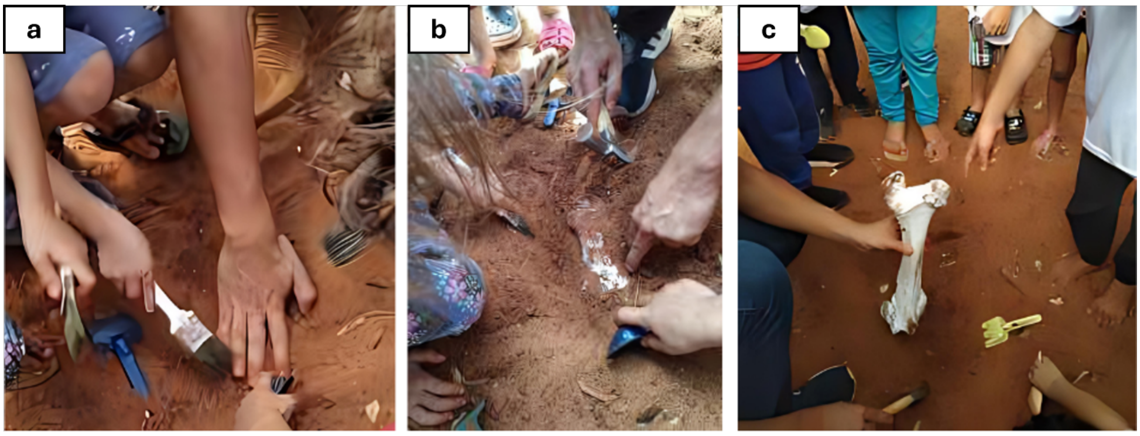

Figure 4. Playful-educational game "Fossil Hunt". a) Children handling brushes and shovels in search of a representational fossil model in the schoolyard sandbox. b) Moment when the children found the model and began the pretend excavation. c) Removal of the model. Source: prepared by the authors.

Prior to the activity, a replica of a long bone fossil was made in plaster and buried in advance in the sandbox. Educators can use other representational models to illustrate fossils. The students received brushes and shovels to search for the fossil, simulating the role of paleontologists. Upon finding it, an explanation was given about what fossils are, how they are formed, paleoenvironmental contexts, and their relation to sedimentary rocks, always making reference to the depth of geological time, although no Eons, Eras, or Periods were mentioned. We observed that the children asked whether it was a real dinosaur fossil. We clarified that it was not, since real fossils, when discovered, are collected by researchers and stored in specific places.

Beyond what has already been presented in Table 2, it is noteworthy that the activity is intended to stimulate child development by: "Allowing them to explore natural environments"; "Talking about 'yesterday,' 'today,' and 'tomorrow'"; "Providing free play"; "Encouraging imagination and explanations of how things work"; "Motor skills: using scissors, forks, spoons, and knives [in this case, the shovels and brushes for excavation]"; "Encouraging singing, dancing, acting, and role-playing"; and "Engaging in pretend situations."

With respect to UDL principles, the activity can be used to provide options and foster interest in the study of fossils. Each child received an individual brush-and-shovel kit to simulate the role of a paleontologist and was able to freely explore the sandbox, thereby respecting self-regulation in the designed path and minimizing insecurity and anxiety that another peer might cause if the excavation were performed simultaneously. The fossil replica could be handled to provide an alternative to the perception of visual information.

5. DISCUSSION

This study culminated in the development of a didactic sequence that integrates playful and educational strategies and resources to teach ES concepts to children, in accordance with national curriculum guidelines and earth science literacy principles, from an inclusive perspective. The didactic sequence developed remained aligned with national curriculum guidelines, with particular emphasis on the BNCC, which establishes specific fields of experience and learning objectives.

In terms of contributions to ES literacy, the study was able to address a variety of concepts such as rock types, natural cycles, and geological time, correlated with international parameters such as "Geological Time," "Earth as a System," "Hydrosphere," "Geosphere," "Atmosphere," and "Biosphere." These were identified by Ponte and Piranha (2020) as concepts that demonstrate the complementarity between the principles and ideas of ES literacy presented by Wysession et al. (2010), Pedrinaci et al. (2013), and King (2014). The inclusion of earth science content in early childhood education curricula is a way to awaken children's curiosity about natural phenomena and the elements that compose the Earth (Gonçalves et al., 2021). We also recall that the year 2023 marked 50 years since the beginning of initiatives and research at the interface between earth sciences and education in Brazil, a field that has been consolidated over the last two decades with significant scientific and technical production (Gonçalves & Conceição, 2023). Despite recognition of the importance of ES education, the integration of such practices into the current curriculum guidelines still poses a challenge, especially in basic education (Imbernon, 2021). The need for playful-pedagogical activities in ES education is particularly pressing in early childhood education, where practices must respect children's development, diversity, and learning rhythms (Pioker-Hara et al., 2024).

Furthermore, the literature emphasizes the importance of earth science exhibitions for early childhood education, stressing that such activities should promote integration among children's cognitive, psychomotor and affective domains (Machado et al., 2021). In previous experiences, activities centered on themes such as paleontology proved effective by employing diverse strategies, including use of songs, children's stories, theater vignettes, costumes, and games related to dinosaurs, in addition to handling fossils (Machado et al., 2021). Another contribution was the potential for diversifying playful-educational activities beyond games, a demand in the field of ES education highlighted by Camargo et al. (2021).

By relating the developmental milestones that can be fostered through the activities of the didactic sequence, we reiterate the findings of Gonçalves et al. (2021), who indicated that ES teaching in early childhood education promotes learning through psychomotor and cognitive development. An inclusive perspective was enabled by incorporating into the activities actions aligned with universal design for learning (UDL) principles, from the design of materials and the organization of the thematic classroom and games to the analysis presented here. According to UDL guidelines, flexibility must be incorporated into the establishment of teaching objectives, the choice of materials, pedagogical methods, and the ways of assessing students' progress (Bettio et al., 2021).

The activities were planned to respect children's diverse learning rhythms, providing multiple stimuli and promoting socialization and affectivity, as indicated by studies of ES teaching for children (Gonçalves et al., 2021; Pioker-Hara et al., 2024). This process of adopting UDL-based practices to make existing curricula more accessible is frequent, but since such adaptations are made after curriculum design, they may not strictly qualify as UDL (Sebastián-Heredero, 2020). It is important to note that although the didactic sequence did not constitute a complete curricular design, it followed UDL principles and could serve as a foundation for future studies aimed at creating inclusive curricular proposals for ES in early childhood education. UDL seeks to meet learner diversity through the use of varied pedagogical resources, materials, techniques, and strategies, facilitating learning and access to the curriculum (Ribeiro & Amato, 2018).

It is worth noting that among UDL principles, according to the CAST (2018) classification, the proposed activities mainly favor the objective of fostering the learning of more resourceful and knowledgeable students, by providing multiple means of representation and options for perception, language, symbols, and comprehension—the recognition networks of the "what" of learning. The adoption of UDL principles legitimizes compliance with the DCNEI in Brazil, which emphasize the importance of social and intersubjective relationships in schools, promoting children's curiosity and development through guided play (Brasil, 2013).

The didactic sequence developed makes a significant contribution to early childhood education by integrating earth science concepts in an inclusive and playful way, aligned with national curriculum guidelines and UDL principles, and promoting ES literacy that respects each child's particularities and development. As for obstacles, the greatest difficulty observed was the simultaneous management of all students in certain experimental and playful activities, as well as the need to adapt some proposals to different levels of motor or cognitive ability. Such limitations were overcome through real-time adjustments, close supervision, and individualized path organization, ensuring that everyone could participate safely and inclusively.

6. FINAL REMARKS

The didactic sequence developed in this study not only addressed earth science content in an accessible and engaging way for children, but also promoted learning that supports early childhood education. By employing diverse pedagogical resources, it was possible to engage children in playful and effective ways, respecting their individualities and fostering the construction of earth science knowledge.

The adoption of UDL principles was crucial for the success of the activities, by providing multiple means of engagement, representation, and expression. This allowed all children, regardless of their abilities and particular developmental rhythms, to participate and learn meaningfully. The proposed activities were anchored in methodological guidelines from CAST, recognized by the academic community and validated by teachers and school administrators, ensuring their applicability and effectiveness.

This study reaffirms the importance of earth science teaching in early childhood education and the need to continue developing and implementing inclusive and diversified pedagogical practices. The integration of UDL principles with the BNCC and the national guidelines for early childhood education proved to be an effective and innovative approach to promote scientific education from the earliest school years. It is innovative from a theoretical-methodological perspective by highlighting a possible articulation among frameworks adopted in other studies on geoscience education and inclusive education: developmental stimuli, educational references and earth science literacy, BNCC fields of experience and learning objectives, and UDL principles. It is also innovative from a practical standpoint by detailing

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the materials and methodology of the different activities that composed the didactic sequence, fostering the replication of playful-educational practices by basic education teachers.

Therefore, we expect this work to serve as a reference for future initiatives in the field, contributing to the consolidation of earth science learning in Brazilian basic education and to the formation of citizens who are more aware and informed about the natural world in which we all live. Although no formal evaluation was conducted, observational data, the use of low-cost materials, and the combination of diverse theoretical-methodological variables made it possible to recognize the replicable potential of the didactic sequence. In future implementations, the inclusion of assessment tools—such as performance records, self-assessments, or structured observations—can complement the study, providing more robust evidence regarding students' learning and perceptions.

REFERENCES

Bacci, D. L. C., & Piranha, J. M. (2020). A geologia e a formação de professores. In F. A. G. V. Reis et al. (Orgs.), *Ensino e competências profissionais na geologia* (Vol. 1, pp. 59–78). FUNEP.

Bacci, D. L. C (2009). A contribuição do conhecimento geológico para a educação ambiental. *Pesquisa em Debate, 11*(6), 2–23.

Bacci, D. L. C. (Org.). (2015). *Geociências e educação ambiental*. Ponto Vital.

Bettio, C. D. B., Miranda, A. C. A., & Schmidt, A. (2021). *Desenho universal para a aprendizagem e ensino inclusivo na educação infantil* (1ª ed.). FFCLRP-USP.

Brasil (1988). *Constituição da República Federativa do Brasil de 1988*. Brasília, DF: Senado Federal.

Brasil (1996). *Lei nº 9.394, de 20 de dezembro de 1996: Estabelece as diretrizes e bases da educação nacional.* Diário Oficial da União, Brasília, DF.

Brasil (2009). *Resolução CNE/CEB nº 5, de 17 de dezembro de 2009*. Diário Oficial da União.

Brasil (2013). *Diretrizes curriculares nacionais gerais da educação*. MEC, SEB, DICEI.

Brasil (2018). *Base Nacional Comum Curricular*. Brasília, DF: MEC.

Camargo, R. P., Ponte, M. L., & Piranha, J. M. (2021). Contribuições de jogos para o ensino de Ciências da Terra: uma revisão da literatura. In C. L. Araujo-Neto, J. C. B. Marinho & W. B. Ferreira (Orgs.), *Ciência se faz com pesquisa* (1ª ed.). Editora Realize.

Cardoso, L. A. (2023). Os conteúdos de geociências na BNCC e nos currículos subnacionais: Análise das habilidades de geografia do 6º ano do Ensino Fundamental. *Revista Tocantinense de Geografia*, 13(29), 54-86.

Carneiro, C. D. R., Gonçalves, P. W., Imbernon, R. A. L., Machado, F. B., & Cerri, C. A. D. (Eds.). (2018). *Ensino e história de ciências da Terra*. Sociedade Brasileira de Geologia.

Carneiro, C. D. C., Toledo, M. C. M., & Almeida, F. F. M. (2004). Dez motivos para a inclusão de temas de geologia na educação básica. *Revista Brasileira de Geociências, 34*(4), 553–560.

Casimiro, M. B. B. (2013). A magia das cores: uma proposta de trabalho em Geociências para a educação infantil. *Geologia USP: Publicação Especial, 6*, 47–54.

CAST. (2018). *Universal design for learning guidelines version 2.2*. Autor.

Compiani, M. (2005). Geologia/Geociências no ensino fundamental e a formação de professores. *Geologia USP: Publicação Especial, 3*, 13–30.

Ernesto, M., Cordani, U. G., Carneiro, C. D. R., Dias, M. A. F. S., Mendonça, C. A., & Braga, E. S. (2018). Perspectivas no ensino de Geociências. *Estudos Avançados, 39*(94), 331–344.

DOI http://dx.doi.org/10.14571/brajets.v18.n3.1109-1129
ISSN 2316-9907

Gonçalves, L. H. M., Carneiro, C. D. R., & Imbernon, R. A. L. (2018). Percepções docentes sobre o ensino de Geociências na educação infantil. In *Anais do 9º Simpósio de Pesquisa em Ensino e História de Ciências da Terra* (pp. 146–150). UNICAMP/IG.

Gonçalves, L. H. M., Grama, É. de A., & Passos, A. P. D. (2021). Atividades em Geociências na educação infantil baseadas em desenho universal de aprendizagem como ferramenta para o desenvolvimento da criança. *Terrae Didática, 17*, e021029.

Gonçalves, P. W., & Conceição, G. K. A. (Orgs.). (2023). *Boletim de resumos do Simpósio Interfaces Geociências e Ensino: 50 anos de experiências no Brasil (1973–2023)*. Universidade Estadual de Campinas, Instituto de Geociências.

Grotzinger, J., & Jordan, T. (2013). *Para entender a Terra* (6ª ed.). Bookman.

Imbernon, R. A. L. (2021). *Atividades da Comissão sobre Geologia na Educação Básica – COGEB da Sociedade Brasileira de Geologia – SBG para 2021*. SBG/COGEB.

King, C. (2015). The international geoscience school syllabus and its development. *Episodes, 38*(1), 57–74.

Latorre, A. (2005). La investigación-acción: Conocer y cambiar la práctica educativa. 3 ed.. Editorial Graó.

Machado, R. R., Rossato, B. C. L., Zadminas, M. R., Roitberg, N. W., Silva, A. P., & Campos, D. A. (2021). Museu itinerante: uma experiência de divulgação da geologia e paleontologia na educação infantil. *Anuário do Instituto de Geociências, 44*, 37294, 1–7.

Melo, R. D., Matos, C. F., Vargas, J. P., & Nicoletti, E. R. (2020). Geodiversidade e o ensino de ciências: uma proposta para a educação infantil. *#Tear: Revista de Educação, Ciência e Tecnologia, 9*(1).

Menegat, R. (2009). Geoparques como laboratórios de inteligência da Terra. *Geologia USP: Publicação Especial, 5*, 91–103.

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

Negreiros, A. R. A., & dos Reis, D. A. (2024). As Geociências na Base Nacional Comum Curricular. *Geoconexões*, 3(20), 252–278.

Oliveira, A. R. P., Munster, M. A. V., & Gonçalves, A. G. (2019). Desenho universal para aprendizagem e educação inclusiva: uma revisão sistemática da literatura internacional. *Revista Brasileira de Educação Especial, 25*(4), 675–690.

Pedrinaci, E., Alcalde, S., Alfaro, P., Almodóvar, G. R., Barrera, J. L., Belmonte, Á., ... & Rebollo, L. (2013). Alfabetización en Ciencias de la Tierra. *Enseñanza de las Ciencias de la Tierra*, *22*(2):117-129.

Perez, C. P., De Andrade, L. C., & Rodrigues, M. F. (2015). Desvendando as Geociências: alfabetização científica em oficinas didáticas para o ensino fundamental em Porto Velho, Rondônia. *Terrae Didática, 11*(1), 42–51.

Pioker-Hara, F. C., Imbernon, R. A. L., & Silva, T. A. S. (2024). Ensinando as Ciências da Natureza em uma perspectiva inclusiva: o Desenho Universal para a Aprendizagem (DUA) no planejamento curricular. In C. D. R. Carneiro (Org.), *Explorando a Terra na Educação Básica* (Vol. 2, pp. 69–86). Universidade Estadual de Campinas.

Piranha, J. M., Bacci, D. L. C., & Del Lama, E. A. (2024). Educação em ciência do sistema Terra na formação de professores. In C. D. R. Carneiro (Org.), *Explorando a Terra na Educação Básica* (Vol. 1, p. 51). Universidade Estadual de Campinas.

Ponte, M. L., & Piranha, J. M. (2020). Ciências da Terra no currículo do estado de São Paulo: uma abordagem reflexiva. *Terrae Didática, 16*, e020005.

Ponte, M. L., de Camargo, R. P., & Piranha, J. M. (2020). Ciência do Sistema Terra no Currículo Paulista: Novo currículo, questões recorrentes. *Simpósio de Tecnologia Fatec Jaboticabal*, 1(1), 166–170.

Ponte, M. L., Camargo, R. P., & Piranha, J. M. (2023). Potencialidades para educação em Ciência do Sistema Terra na Base Nacional Comum Curricular. *Estudos Geográficos: Revista Eletrônica de Geografia*, 21(2), 40–53.

Ribeiro, G. R. P. S., & Amato, C. A. L. H. (2018). Análise da utilização do desenho universal para aprendizagem. *Cadernos de Pós-Graduação em Distúrbios do Desenvolvimento, 18*(2), 125–151.

Sebastián-Heredero, E. (2020). Diretrizes para o desenho universal para a aprendizagem (DUA). *Revista Brasileira de Educação Especial, 26*(4), 733–768.

Silva-Junior, A. S., & Dantas, I. S. (2022). O Desenho Universal da Aprendizagem-DUA: uma ferramenta de inclusão na Educação Infantil. Ensino em Perspectivas, 3(1), 1–6.

Smile and Learning – Português. (2020, 2 de janeiro). O ciclo da água para crianças - O que é o ciclo da água - Ciências para crianças [Vídeo]. *YouTube*. https://youtu.be/KZTRy6KL7_c?si=JXV5LnY8N5z-0px0

Teixeira, D. M., Machado, F. B., & Silva, J. S. da. (2017). O lúdico e o ensino de Geociências no Brasil: principais tendências das publicações na área de Ciências da Natureza. Terrae Didatica, 13(3), 286–294. https://doi.org/10.20396/td.v13i3.8650004

Toledo, M. C. M. (2005). Geociências no Ensino Médio Brasileiro – Análise dos Parâmetros Curriculares Nacionais. Geologia USP – Publicação Especial, 3, 31–44.

Toledo, M. C. M., Macedo, A. B., Machado, R., Martins, V. T. S., Riccomini, C., Santos, P. R., Silva, M. E., & Teixeira, W. (2005). Projeto de criação do curso de licenciatura em geociências e educação ambiental – Instituto de Geociências/USP. *Geologia USP – Publicação Especial*, 3, 1–11.

Wysession, M., Taber, J., Budd, D. A., Campbell, K., Conklin, M., LaDue, N., ... & Tuddenham, P. (2010). *Earth Science Literacy*: the big ideas and supporting concepts of Earth Science. National Science Foundation.

Zerbato, A. P., & Mendes, E. G. (2018). Desenho universal para a aprendizagem como estratégia de inclusão escolar. *Educação Unisinos*, 22(2), 147–155.