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WHAT TO TEACH ABOUT EARTH SCIENCES IN EARLY CHILDHOOD EDUCATION?: A CURRICULUM ANALYSIS

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Abstract

Scientific content is addressed in schools from the early stages of education. Among these, those related to Earth Sciences provide an understanding of the environment that makes them crucial for facing the new challenges that society confronts. The Early Childhood Education stage is considered ideal for an initial approach to understanding our planet, thereby laying a foundation upon which to build future knowledge. The present study aims to analyse aspects related to Earth Sciences and their treatment in the current Spanish educational law for this stage. To achieve this, a content analysis methodology was employed to examine the law. The results conclude that various fundamental concepts could be introduced in the preschool classroom through Earth Sciences. However, in many instances, the wording of the law refers to science in a general sense, leaving it to the discretion of educators to decide whether to address them in Early Childhood Education. In this context, teacher training is crucial to provide educators with the knowledge and skills necessary to address these concepts in this educational stage.

Keywords – Earth Sciences, Early Childhood Education, Educational legislation, Curriculum, LOMLOE.

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1. Introduction

Early Childhood Education is a crucial period for children to connect with their surroundings, allowing them to begin understanding the processes that occur within it. The current regulatory framework in Spain for this stage (Royal Decree 95/2022, of February 1, establishing the structure and minimum teachings of Early Childhood Education, within the framework of Organic Law 3/2020, of December

29, which amends Organic Law 2/2006, of May 3, on Education) accommodates the initial introduction of science to children. The legal basis regulating scientific teachings must enable these children to respond and act reasonably and critically to the challenges society faces now and in the future. Thus, Early Childhood Education is the time to start working on scientific literacy among students, which "entails acquiring basic elements for understanding science and technology so that this knowledge can be used in communication and argumentation with a scientific basis and, where appropriate, in pronouncements on scientific issues and their derivations in what pertains to civic action" (Marco-Stiefel, 2004: page 274). Within this broad framework of scientific literacy lies the concept of literacy in Earth Sciences (ES).

1.1. Literacy in Earth Sciences

Within the broad framework provided by scientific literacy, the potential that an objective understanding of ES offers makes it a fundamental tool for addressing the new challenges and issues of 21st-century society (Korkmaz & Altinsoy, 2023). In this context, the literacy in ES is defined as related to the understanding of the history, characteristics, and functioning of our planet (Lacreu, 1999). In Spain, the contribution of Emilio Pedrinaci and collaborators was pivotal with the publication of the work "Literacy in Earth Sciences" (Pedrinaci, Alcalde, Alfaro, Almodóvar, Barrera, Belmonte et al., 2013). This manifesto was supported by various leading institutions in the field of science in Spain (Geological Society of Spain, Royal Society of Natural History, Official College of Geologists, and the Confederation of Scientific Societies of Spain, among many others). It highlighted that the educational system did not clearly address this need, failing to give geology the importance it holds. Based on the principles established by the National Science Foundation (National Science Foundation, 2009), Pedrinaci et al. (2013) defined the 10 key ideas (KI) that every citizen should know about the Earth and its functioning, each of which is developed into a set of knowledge that includes the concepts and principles that underpin them (Table 1).

Key ideas	
KI1	Earth is a complex system where rocks, water, air, and life interact.
KI2	The origin of Earth is tied to that of the Solar System, and its long history is recorded in the materials that compose it.
KI3	Earth's materials are continuously created and modified.
KI4	Water and air make Earth a special planet.
KI5	Life evolves and interacts with Earth, mutually modifying each other.
KI6	Plate tectonics is a global and integrative theory of Earth.
KI7	External geological processes transform the Earth's surface.
KI8	Humanity depends on Earth for resources and must do so sustainably.
KI9	Some natural processes pose risks to humanity.
KI10	Scientists interpret and explain Earth's functioning based on repeatable observations and verifiable ideas.

Table 1. Key ideas (KI) for Earth Sciences literacy established by the "What Geology to Teach" commission (Pedrinaci et al., 2013)

Despite the importance of these KI and ES for understanding our environment, previous educational curricula in Spain have not treated this discipline with the appropriate significance (Iglesias & Calonge, 2018), not only in secondary education but also in earlier educational levels (Pedrinaci, 2012). Every citizen should possess basic notions about the origin and functioning of the planet we live on to inhabit and care for it with appropriate criteria (Pedrinaci, 2016). This becomes necessary within the framework of education for sustainability (Kalogiannakis, Rekoumi, Antipa & Poulou, 2010) and the Sustainable Development Goals (SDGs), and its acquisition should begin in the early years of schooling (van Vuuren, 2023).

1.2. Earth Sciences in Early Childhood Education

Early Childhood Education is considered an ideal period for an initial encounter with science (French, 2004). Internationally, several curricular recommendations have been proposed that include science teaching at this stage with varying depth, notably those developed by the National Research Council and The Next Generation Science Standards, both in the USA (National Research Council, 2012; NGSS Lead States, 2013). In these proposals, ES are valued as an indispensable tool for civic education. This is not the only example in the international context, as the literature documents different methodological approaches to ES for this stage (Green, 2015). For example, in Greece, the initiation into geological processes and hazards has been explored (Kalogiannakis et al., 2010); in Israel, the history of planet Earth and astronomy (Raviv & Dadon, 2021); in Germany, evolution (Bruckermann, Fiedler & Harms, 2021); in China, energy resources (Zhang, Wang, Wang, Gao, Zhu & Song, 2021); and in Japan and Australia, among other countries, environmental care (Inoue, Elliott, Mitsuhashi & Kido, 2019). This educational approach in early childhood is necessary to understand the world around them and to inhabit it sustainably (Wolff, Skarstein & Skarstein, 2020).

The curricular framework is crucial as it determines the knowledge about our planet and sustainability that students must acquire (Weldemariam, Boyd, Hirst, Sageidet, Browder, Grogan et al., 2017) to meet the SDGs defined by the UN in 2015 and included in the 2030 Agenda for Sustainable Development (Medina & Galván, 2021). In the Spanish curriculum, there have been modifications in general scientific content and specifically related to ES, in accordance with the implementation of the current educational curriculum.

Therefore, the main objective of this work is to review the presence and adequacy of aspects related to our planet, from the ES perspective, in the current curriculum for Early Childhood Education in Spain. Additionally, it aims to verify whether these aspects included in the curriculum for the early educational years are aligned with the ten KI related to ES that should begin to be addressed in the early years of education (Pedrinaci et al., 2013), engaging in a reflection on how to effectively implement them.

To this end, a novel approach is proposed, through which curricular elements related to Earth Sciences are analysed by examining the proposed content in terms of the basic knowledge areas and the competency-based framework in which they are embedded, along with the associated evaluation criteria.

2. Methodology

To achieve the proposed objectives, a novel mixed-methodology, quantitative and qualitative, was conducted through descriptive and interpretative content analysis of documents in contrast with the KI proposed by Pedrinaci et al. (2013), which are aligned with the Earth Science Literacy Principles (National Science Foundation, 2009). The methodology followed the steps summarized by Islas (2020), which consolidate recommendations from various authors (Stemler, 2000; Fernández, 2002).

In this study, a review was conducted of the current regulatory framework establishing the structure and minimum teachings for the Early Childhood Education stage in Spain (Royal Decree 95/2022, of February 1). Based on this document, a review of the national curricular regulations was carried out to identify elements reflected in the curriculum related to the teaching of ES.

The units of analysis established in this study are the curricular elements that could be approached from the perspective of ES. Subsequently, a correlation was made between the basic knowledge and the ten KI previously mentioned (Pedrinaci et al., 2013). This correlation allowed for the calculation of relative and absolute percentages of the presence of these KI in the curriculum, both isolated for each cycle and overall, for the early childhood stage. The percentage analysis was performed by counting the number of records obtained for each key idea after the correlation process, analyzing which areas and sections of the curriculum offer scope for the teaching of ES. The correlation of basic knowledge to the KI was independently performed by two researchers. The value of Cohen's Kappa inter-rater agreement coefficient (Field, 2024), 0.9, showed excellent results. Existing differences were discussed by both researchers, consulting an external expert in Geology Didactics in case of doubt until consensus was reached.

3. Results

The current regulatory framework establishes that Early Childhood Education in Spain is divided into two cycles, for which three main areas of work are defined: 1) Growth in Harmony, 2) Discovery and Exploration of the Environment, and 3) Communication and Representation of Reality. It is in the second area that curricular elements related to ES have been identified.

Area 2, "Discovery and Exploration of the Environment", is oriented towards the development of thinking and cognitive strategies through the process of discovering the physical and natural environment (Royal Decree 95/2022: page 20). This process aims to promote children's curiosity about their everyday surroundings, encouraging them to question aspects of their daily lives and begin to provide reasoned solutions that shape their respectful approach towards the natural environment. Specifically, it is stated that:

"This area aims to promote the process of discovery, observation, and exploration of the physical and natural elements of the environment, conceiving it as a trigger for emotions and surprises, and ensuring that, along with their progressive knowledge, children adopt and develop attitudes of respect and appreciation for the need to care for and protect it" (Royal Decree 95/2022: page 20).

This area is organized around three key competencies that affect both the first and second cycles: mathematical competence and competence in science, technology, and engineering; personal, social, and learning to learn competence; and citizenship competence. In this regard, the curriculum states that:

"The first is oriented towards the development of skills that help identify and establish logical relationships between the various elements that are part of the environment; the second focuses on fostering a critical and creative attitude to identify challenges and propose possible solutions; and the third involves a respectful approach to the natural world to awaken the awareness of the need to make sustainable use of it, ensuring its care and conservation" (Royal Decree 95/2022: page 21). Therefore, scientific issues, particularly those related to ES, are encompassed within all three competencies.

Specific competencies related to the introduction to science, and particularly to the natural environment, are also defined. These competencies are shared across both cycles of Early Childhood Education and serve as the foundation upon which the assessment criteria are built. Through their development, children are expected to begin acquiring skills to observe, explore, and make sense of the natural world around them, fostering curiosity and critical thinking from an early age. Environmental exploration activities encourage the recognition of natural elements and phenomena, as well as an understanding of the impact of human actions on the environment, thereby laying the groundwork for ecological awareness and sustainable thinking.

Additionally, scientific processes that should be included in the educational programming of this area are also outlined. It is proposed that through various learning situations involving interaction with different objects, spaces, and materials, students learn to manipulate, observe, inquire, test, identify, relate, analyze, verify, and reason, among other skills (Royal Decree 95/2022: page 22).

To evaluate the achievement of the specific competencies in each cycle, evaluation criteria corresponding to each of them are specified (Tables 2 and 3), referencing the basic knowledge they pertain to. This basic knowledge is divided into three sections for this area: Section A (SA) "Bodily dialogue with the environment. Creative exploration of objects, materials, and spaces"; Section B (SB) "Experimentation in the environment. Curiosity, scientific thinking, and creativity"; Section C (SC) "Inquiry into the physical and natural environment. Care, appreciation, and respect."

3.1. First cycle of Early Childhood Education

Analyzing the scientific aspects included in the curriculum for this first cycle of Early Childhood Education, the results of the document review show that the focus is primarily on general aspects of self-awareness (both physical and attitudinal), understanding the immediate environment, and developing social behaviors (Table 2). There are not many explicitly mentioned conceptual content; rather, the emphasis is on basic knowledge aimed at developing attitudes for an initial approach to the scientific field and the surrounding nature.

Objectives	b) Observe and explore their familial, natural, and social environment. g) Begin to develop logical-mathematical skills, reading and writing, and movement, gesture, and rhythm.
Key competencies	- Mathematical competence and competence in science, technology, and engineering. - Personal, social, and learning to learn competence. - Citizenship competence.
Specific competencies	1. Identify the characteristics of materials, objects, and collections and establish relationships between them through exploration, sensory manipulation, the use of simple tools, and the development of logical-mathematical skills to discover and create an increasingly complex understanding of the world. 2. Gradually develop the procedures of the scientific method and computational thinking skills through processes of observation and manipulation of objects to begin interpreting the environment and responding creatively to the situations and challenges presented. 3. Recognize elements and phenomena of nature, showing interest in habits that affect it, to appreciate the importance of sustainable use, care, and conservation of the environment in people's lives.
Evaluation criteria	CE1.1 Relate objects based on their basic qualities or attributes, showing curiosity and interest. CE1.2 Use the most significant basic quantifiers related to their daily experience, applying them in the context of play and interaction with others. CE1.3 Apply their knowledge of basic spatial notions to position themselves in spaces, both at rest and in motion, by playing with their own body and objects. CE2.1 Manage difficulties, challenges, and problems with interest and initiative by breaking them down into sequences of simpler activities. CE2.2 Propose solutions and alternatives through different strategies, while listening to and respecting those of others. CE3.1 Show interest in activities involving contact with nature and the characteristics of natural elements in the environment, demonstrating respect for them and the animals that inhabit it. CE3.2 Identify and name common weather phenomena in their environment, explaining their consequences in daily life.
Basic knowledge	SECTION A: Bodily Dialogue with the Environment. Creative Exploration of Objects, Materials, and Spaces. - Curiosity and interest in exploring the environment and its elements. - Exploration of objects and materials through the senses. - Identification of the qualities or attributes of objects and materials. Effects produced by different actions on them. - Basic temporal notions: change and permanence, continuity; succession and simultaneity; past, present, and future. - Relationships of order, correspondence, classification, and comparison. SECTION B: Experimentation in the Environment. Curiosity, Scientific Thinking, Logical Reasoning, and Creativity. - Inquiry into the environment demonstrating various attitudes: interest, curiosity, imagination, creativity, and surprise. - The construction of new knowledge: relationships and connections between the known and the novel; support and quality interactions with adults, peers, and the environment. - Model of variable control. Strategies and techniques of investigation: trial and error, observation, verification, and asking questions. SECTION C: Inquiry into the Physical and Natural Environment: Care, Appreciation, and Respect. - Effects of one's actions on the physical environment and natural and cultural heritage.

	- Experimentation with natural elements. - Common natural phenomena: impact on daily life. - Respect for nature, living beings, and animal rights. - Respect for cultural heritage present in the physical environment.
Learning situations	It is proposed to design stimulating, meaningful, and integrative learning situations that are well contextualized and respectful of the students' comprehensive development process in all its dimensions. These should consider their potential, interests, and needs, as well as the different ways of understanding reality at each stage of their development.

Table 2. Summary of aspects incorporating ES in Area 2: Discovery and Exploration of the Environment for the first cycle of Early Childhood Education (Royal Decree 95/2022)

3.2. Second cycle of Early Childhood Education

In the second cycle, some of the minimum knowledge requirements are already specifically related to the field of ES (Table 3).

Objectives	b) Observe and explore their familial, natural, and social environment. g) Begin to develop logical-mathematical skills, reading and writing, and movement, gesture, and rhythm.
Key competencies	- Mathematical competence and competence in science, technology, and engineering. - Personal, social, and learning to learn competence. - Citizenship competence.
Specific competencies	1. Identify the characteristics of materials, objects, and collections and establish relationships between them through exploration, sensory manipulation, the use of simple tools, and the development of logical-mathematical skills to discover and create an increasingly complex understanding of the world. 2. Gradually develop the procedures of the scientific method and computational thinking skills through processes of observation and manipulation of objects to begin interpreting the environment and responding creatively to the situations and challenges presented. 3. Recognize elements and phenomena of nature, showing interest in habits that affect it, to appreciate the importance of sustainable use, care, and conservation of the environment in people's lives.
Evaluation criteria	CE1.1 Establish different relationships between objects based on their qualities or attributes, showing curiosity and interest. CE1.5 Organize their activity by sequencing and using basic temporal notions. CE2.1 Manage situations, difficulties, challenges, or problems through the planning of activity sequences, demonstrating interest and initiative, and cooperating with peers. CE2.2 Gradually channel frustration in the face of difficulties or problems by applying different strategies. CE2.3 Formulate hypotheses about the behavior of certain elements or materials and verify them through manipulation and action. CE2.4 Use different strategies for decision-making with increasing autonomy, addressing the process of creating original solutions in response to challenges. CE2.6 Participate in projects using cooperative dynamics, sharing and valuing their own and others' opinions, and expressing personal conclusions based on them. CE3.1 Show an attitude of respect, care, and protection towards the natural environment and animals, identifying the positive or negative impact of some human actions on them. CE3.2 Identify common and different traits between living and non-living beings. CE3.3 Establish relationships between the natural and social environment based on the knowledge and observation of some natural phenomena and the heritage elements present in the physical environment.
Basic knowledge	SECTION A: Bodily Dialogue with the Environment. Creative Exploration of Objects, Materials, and Spaces. - Qualities or attributes of objects and materials. Relationships of order, correspondence, classification, and comparison. - Contextualized basic quantifiers. - Situations where measurement is necessary. - Time and its organization: day-night, seasons, cycles, calendar, etc. SECTION B: Experimentation in the Environment. Curiosity, Scientific Thinking, Logical Reasoning, and Creativity.

	- Guidelines for inquiry into the environment: interest, respect, curiosity, wonder, questioning, and a desire for knowledge. - Strategies for building new knowledge: relationships and connections between what is known and new, and between previous and new experiences; scaffolding and quality interactions with adults, peers, and the environment. - Model of variable control. Strategies and techniques of investigation: trial and error, observation, experimentation, formulation and verification of hypotheses, asking questions, handling and searching in different information sources. - Strategies for planning, organizing, or self-regulating tasks. Initiative in seeking agreements or consensus in decision-making. - Strategies for proposing solutions: creativity, dialogue, imagination, and discovery. - Processes and results. Findings, verification, and conclusions.
Basic knowledge	SECTION C: Inquiry into the Physical and Natural Environment: Care, Appreciation, and Respect. - Natural elements (water, earth, and air). Characteristics and behavior (weight, capacity, volume, mixtures, or transfers). - Influence of human actions on the physical environment and natural and cultural heritage. Climate change. - Natural resources. Sustainability, clean, and natural energies. - Natural phenomena: identification and impact on people's lives. - Respect and protection of the natural environment. - Respect for the cultural heritage present in the physical environment.
Learning situations	It is proposed to design stimulating, meaningful, and integrative learning situations that are well contextualized and respectful of the students' comprehensive development process in all its dimensions. These should consider their potential, interests, and needs, as well as the different ways of understanding reality at each stage of their development.

Table 3. Summary of aspects incorporating ES in Area 2: Discovery and Exploration of the Environment, for the second cycle of Early Childhood Education (Royal Decree 95/2022)

3.3. Correspondence between basic knowledge and the ten key ideas for effective teaching of Earth Sciences

Table 4 presents the association of selected basic knowledge according to its correspondence with the KI defined by Pedrinaci et al. (2013).

Key Ideas (KI)	Basic knowledge for the first cycle of Early Childhood Education	Basic knowledge for the second cycle of Early Childhood Education
KI1 The Earth is a complex system in which rocks, water, air, and life interact.	- Curiosity and interest in exploring the environment and its elements. (SA) - Relationships of order, correspondence, classification, and comparison. (SA)	- The concept of time and its organization: day-night, seasons, cycles, calendar, etc. (SA) - Natural elements (water, earth, and air). Characteristics and behaviour (weight, capacity, volume, mixtures or transfers). (SC) - Influence of human actions on the physical environment and natural and cultural heritage. Climate change. (SC) - Respect and protection of the natural environment. (SC)
KI2 The origin of the Earth is linked to that of the Solar System, and its long history is recorded in the materials that compose it.	- Basic temporal notions: change and permanence, continuity; succession and simultaneity; past, present, and future. (SA)	- The concept of time and its organization: day-night, seasons, cycles, calendar, etc. (SA) - Influence of human actions on the physical environment and natural and cultural heritage. Climate change. (SC) - Respect and protection of the natural environment. (SC)

Key Ideas (KI)	Basic knowledge for the first cycle of Early Childhood Education	Basic knowledge for the second cycle of Early Childhood Education
KI3 The materials of the Earth are continuously forming and modifying.	- Exploration of objects and materials through the senses. (SA) - Identification of the qualities or attributes of objects and materials. Effects produced by different actions on them. (SA)	- Natural elements (water, earth, and air). Characteristics and behaviour (weight, capacity, volume, mixtures or transfers). (SC)
KI4 Water and air make Earth a special planet.	- Curiosity and interest in exploring the environment and its elements. (SA)	- Qualities or attributes of objects and materials. Relations of order, correspondence, classification, and comparison. (SA) - Natural elements (water, earth, and air). Characteristics and behaviour (weight, capacity, volume, mixtures or transfers). (SC) - Natural resources. Sustainability, clean and natural energies. (SC) - Respect and protection of the natural environment. (SC)
KI5 Life evolves and interacts with the Earth, mutually modifying each other.	- Basic temporal notions: change and permanence, continuity; succession and simultaneity; past, present, and future. (SA)	- Respect and protection of the natural environment. (SC) - Respect for the cultural heritage present in the physical environment. (SC)
KI6 Plate tectonics is a global and integrative theory of the Earth.	- Not founded	- Natural phenomena: identification and impact on people's lives. (SC)
KI7 External geological processes transform the Earth's surface.	- Not founded	- Natural resources. Sustainability, clean and natural energies. (SC) - Natural phenomena: identification and impact on people's lives. (SC)
KI8 Humanity depends on the planet Earth for its resources and must do so sustainably.	- Effects of one's own actions on the physical environment and on natural and cultural heritage. (SC) - Common natural phenomena: impact on everyday life. (SC) - Respect for nature, living beings, and animal rights. (SC) - Respect for the cultural heritage present in the physical environment. (SC)	- Influence of human actions on the physical environment and natural and cultural heritage. Climate change. (SC) - Natural resources. Sustainability, clean and natural energies. (SC) - Respect and protection of the natural environment. (SC) - Respect for the cultural heritage present in the physical environment. (SC)
KI9 Some natural processes pose risks to humanity.	- Effects of one's own actions on the physical environment and on natural and cultural heritage. (SC) - Common natural phenomena: impact on everyday life. (SC)	- Influence of human actions on the physical environment and natural and cultural heritage. Climate change. (SC) - Natural phenomena: identification and impact on people's lives. (SC)

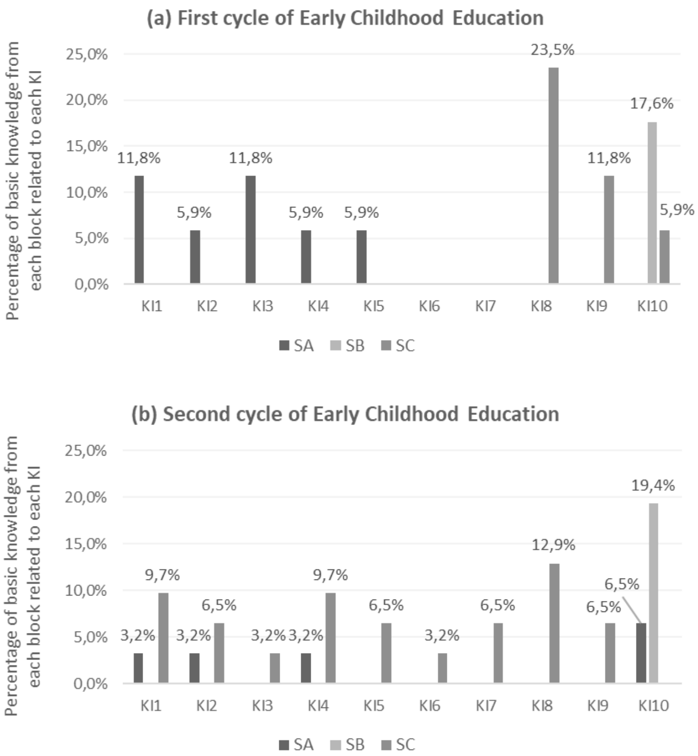
Key Ideas (KI)	Basic knowledge for the first cycle of Early Childhood Education	Basic knowledge for the second cycle of Early Childhood Education
KI10 Scientists interpret and explain the functioning of the Earth based on repeatable observations and verifiable ideas.	- Inquiry into the environment demonstrating various attitudes: interest, curiosity, imagination, creativity, and surprise. (SB) - The construction of new knowledge: relationships and connections between the known and the novel; support and quality interactions with adults, peers, and the environment. (SB) - Variable control model. Research strategies and techniques: trial and error, observation, verification, and asking questions. (SB) - Experimentation with natural elements. (SC)	- Contextualized basic quantifiers. (SA) - Situations where measurement is necessary. (SA) - Guidelines for inquiry into the environment: interest, respect, curiosity, wonder, questioning, and desire for knowledge. (SB) - Strategies for building new knowledge: relationships and connections between the known and the new, and between previous and new experiences; scaffolding and quality interactions with adults, peers, and the environment. (SB) - Variable control model. Research strategies and techniques: trial and error, observation, experimentation, hypothesis formulation and verification, asking questions, and searching and handling various information sources. (SB) - Strategies for planning, organizing, or self-regulating tasks. Initiative in seeking agreements or consensus in decision-making. (SB) - Strategies for proposing solutions: creativity, dialogue, imagination, and discovery. (SB) - Processes and results. Findings, verification, and conclusions. (SB)

SA: Section A (Bodily dialogue with the environment. Creative exploration of objects, materials, and spaces.);
SB: Section B (Experimentation in the environment. Curiosity, scientific thinking, logical reasoning, and creativity.);
SC: Section C (Inquiry into the physical and natural environment: care, appreciation, and respect.)

Table 4. Association between the 10 KI proposed by Pedrinaci et al. (2013) and the basic knowledge related to ES in Area 2 “Discovery and Exploration of the Environment”

In the first cycle of Early Childhood Education (Figure 1a), it can be observed that the basic knowledge that can be taught through ES (a total of 13) could be linked to eight of the ten KI. Section B is the least relevant in this first cycle, with the associated knowledge linked only to KI10 (17.6% of the total basic knowledge associated with ES in this cycle). Section A and Section C encompasses the most related basic knowledge (each section with 41.2% of the total basic knowledge associated with ES in the cycle), grouped for KI1 to KI5 in Section A, and Section C, only grouped for KI8, KI9, and KI10. As reflected in Table 5, the KI that could be most extensively addressed in this cycle are KI8 “Humanity depends on planet Earth for its resources and must do so sustainably” (23.5% of the total knowledge associated with ES in the cycle) and KI10 “Scientists interpret and explain the functioning of the Earth based on repeatable observations and verifiable ideas” (23.5% of the total knowledge associated with ES in the cycle). Meanwhile, those least related to the early childhood curriculum in this cycle are KI6 “Plate tectonics is a global and integrative theory of the Earth” and KI7 “External geological processes transform the Earth’s surface,” which are not reflected in any section.

In the second cycle of Early Childhood Education (Figure 1b), all KI can be addressed (Table 5), and a greater number of knowledge elements can integrate them (a total of 16). Although not all of them refer directly to the KI, as they broadly address scientific issues, they do not exclude them either. It can be observed that Section A includes the fewest basic knowledge elements related to ES (16.1% of the total basic knowledge associated with ES in this cycle), while Section C contains the highest proportion (64.5% of the total basic knowledge associated with ES in this cycle). Moreover, this last section of basic knowledge is the most conducive to addressing a greater number of KI, potentially covering all the KI proposed by Pedrinaci et al. (2013), except for KI10 (“Scientists interpret and explain the functioning of the Earth based on repeatable observations and verifiable ideas”).



SA: Section A (Physical interaction with the environment. Creative exploration of objects, materials, and spaces);
SB: Section B (Experimentation in the environment. Curiosity, scientific thinking, logical reasoning, and creativity);
SC: Section C (Inquiry into the physical and natural environment: care, appreciation, and respect).

Figure 1. Percentage of basic knowledge from each section, calculated relative to the total basic knowledge encompassing ES for each cycle with the KI proposed by Pedrinaci et al. (2013), for the first cycle (a) and the second cycle (b) of Early Childhood Education

Nevertheless, in this second cycle, KI10 is the most represented (25.8% of the total knowledge associated with ES in the cycle), as it can be addressed through all the basic knowledge in Section B, which largely pertains to knowledge and processes related to the scientific method. The least represented KI in this cycle is KI3 "The materials of the Earth are continuously formed and modified" and KI6 "Plate tectonics is a global and integrative theory of the Earth", both with a 3.2% relation to the total basic knowledge associated with ES for this cycle.

The results, considering the entire Early Childhood Education stage (Table 5), show that the most represented KI are KI8 "Humanity depends on planet Earth for its resources and must do so sustainably" (18.2% of the knowledge linked to ES for this stage) and KI10 "Scientists interpret and explain the functioning of the Earth based on repeatable observations and verifiable ideas" (24.7% of the mentioned knowledge). The least present KI in the curriculum for this stage are KI6 "Plate tectonics is a global and integrative theory of the Earth" (1.6% of the total knowledge associated with ES for the stage) and KI7 "External geological processes transform the Earth's surface" (3.2% of the total of such knowledge), both referring to large scales more suitable for cognitive development of Primary school children.

Key Ideas (KI)	First cycle (n)	% (N=17) 1st cycle	Second cycle (n)	% (N=31) 2nd cycle	Total (n)	% (N=48) 1st y 2nd cycle
KI1	2	11.8	4	12.9	6	12.3
KI2	1	5.9	3	9.7	4	7.8
KI3	2	11.8	1	3.2	3	7.5
KI4	1	5.9	4	12.9	5	9.4
KI5	1	5.9	2	6.5	3	6.2
KI6	0	0.0	1	3.2	1	1.6
KI7	0	0.0	2	6.5	2	3.2
KI8	4	23.5	4	12.9	8	18.2
KI9	2	11.8	2	6.5	4	9.1
KI10	4	23.5	8	25.8	12	24.7
Total	17	35.4	31	64.6	48	100.0

n: number of basic knowledge items associated with different KI. %: percentages of basic knowledge associated with different KI for each cycle, calculated relative to the total knowledge of that cycle (Ni), and overall, for the Early Childhood Education stage.

Table 5. Association between basic knowledge and the ten KI for effective teaching of Geology (Pedrinaci et al., 2013)

4. Discussion

A distinctive contribution of this study lies in its detailed analysis of the basic knowledge through the lens of the key ideas proposed by Pedrinaci et al. (2013), which are aligned with the Earth Science Literacy Principles (National Science Foundation, 2009). This analytical framework, which connects curriculum content to foundational principles of Earth Science literacy, represents a novel methodological approach that, to the best of our knowledge, has not yet been applied either to the specific stage of Early Childhood Education within the LOMLOE curriculum or more broadly in international studies. By operationalizing these key ideas as criteria for examining curricular content, this study offers a pioneering contribution to the quantification and evaluation of Earth Science representation in educational programs.

The results of the curricular analysis show that, in the first cycle of Early Childhood Education, the legislative framework only provides basic, general guidelines related to the scientific domain. These guidelines are broadly formulated, allowing for the inclusion of content related to ES. Therefore, for classroom application, topics such as geological materials and their processes through the landscape observation, or rocks and minerals from the local environment appreciation, could be included as study subjects. Employing recreational (García-Marigómez, Ortega-Quevedo & Gil-Puente, 2023), experiential (Mateo & Sáez-Bondía, 2022), manipulative (Elkin-Postila, 2022), artistic (Twomey, O'Siorain, Shevlin & McGuckin, 2021), and classification approaches (Nxumalo, 2017), would be beneficial to integrate these contents (Cruz-Guzmán, Puig & García-Carmona, 2020). However, this broad formulation, which accommodates various didactic approaches, also opens the possibility that ES may not be brought into the classroom, as the curriculum could be developed focusing on other aspects of the natural environment. This potential gap becomes particularly relevant when considering that the curriculum also establishes a set of specific competencies aimed at fostering early scientific thinking, especially through interaction with the natural environment. These competencies, which are common to both educational cycles, form the basis for assessment criteria and are intended to guide learning towards the development of observation, exploration, and reasoning skills. In this sense, the natural environment is not merely a thematic axis but a pedagogical context in which children are invited to engage actively with scientific phenomena. When implemented meaningfully, this competency-based structure provides a framework that supports early scientific literacy, laying the foundations for ecological awareness and sustainability-oriented thinking —objectives that are consistent with a comprehensive approach to Earth Science education.

Analysing the distribution of scientific content in the basic knowledge defined for the second cycle of Early Childhood Education, it is noted that some content related to ES is not explicitly reflected in this new reform, as was the case in the previous law for this stage (García-Yelo, Buitrago & García, 2022). This situation is similarly observed internationally in other curricula, like the American science curriculum, where additionally, ES-related content is the least represented at this stage (Greenfield, Jirout, Dominguez, Greenberg, Maier & Fuccillo, 2009). Nevertheless, in the case of the Spanish curriculum LOMLOE, based on the results obtained in this analysis, sufficiently broad basic knowledge give place to cover ES in this cycle.

Overall, the current curriculum allows for a first introduction to all the KI proposed by Pedrinaci et al. (2013) in Early Childhood Education. The KI that could be most extensively addressed are KI8 “Humanity depends on planet Earth for its resources and must do so sustainably” (especially aligned with the Sustainable Development Goals) and KI10 “Scientists interpret and explain the functioning of the Earth based on repeatable observations and verifiable ideas” (linked to scientific work). The least represented KI are KI6 “Plate tectonics is a global and integrative theory of the Earth” and KI7 “External geological processes transform the Earth’s surface”, as these ideas require an understanding of broad and complex spatial and temporal scales for a preschool child (van Den Broek, Kendeou, Kremer, Lynch, Butler, White et al., 2005). In general, a wide range of curricular elements that could be addressed through ES has been identified. The decision to tackle them ultimately rests with each school and, ultimately, with Early Childhood Education teachers.

In this context, numerous studies indicate that content related to ES is seldom given the same time and effort as other subjects (Early, Iruka, Ritchie, Barbarin, Winn, Crawford et al., 2010). This could be attributed to a lack of scientific and pedagogical knowledge among teachers (Garbett, 2003), low levels of self-efficacy (Opperman, Brunner & Anders, 2019), a prioritization of language and literacy teaching in these early years (Guo, Wang, Hall & Busch, 2016), or a greater emphasis on biology-related content over static natural elements (Wandersee & Schussler, 1999; Almeida, García Fernández & Rodrigues, 2020; Achurra, Berreteaga & Zamalloa, 2023). This underscores the need for education faculties to reinforce ES training for future early childhood educators to ensure geological elements and processes are given the necessary importance.

In the educational sphere, addressing ES, like other similarly complex topics such as climate change, faces several challenges for proper classroom instruction: the difficulty of teaching complex content related to non-visible scales (García Fernández & Sánchez Vizcaíno, 2016); the need to teach this topic with scientific rigor; the limited training of teachers on this subject; and the dissemination of inaccurate information in media, movies, cartoons, or books, which influences both students’ and teachers’ knowledge and perceptions (Morote & Olcina-Cantos, 2023). Despite these challenges, ES education should begin in Early Childhood Education (Kalogiannakis et al., 2010).

In this context, it is suggested that the curriculum should prioritize the sequential introduction of foundational knowledge, beginning with concepts associated with directly observable phenomena. The classroom should be conceived as a space for multisensory, hands-on experiences that go beyond visual engagement, fostering learning through direct interaction with materials. Activities that involve the manipulation of geological specimens—such as reproductions of fossils or different types of rocks—allow children to explore through touch, a fundamental sense at this developmental stage. While museum visits can offer valuable exposure to scientific content (Prieto, Mateos & García Fernández, 2024), they often prioritize visual observation and limit tactile interaction, reducing the depth of learning for young children. In contrast, outings to natural environments represent highly valuable educational opportunities, as they allow children to observe and engage with geological formations, landforms, and materials *in situ*, promoting experiential learning and environmental connection (Almeida, Prieto & García Fernández, 2025). The educational setting must therefore provide a balanced combination of in-class manipulative resources and contextualized outdoor experiences that support the development of early scientific models —precursor models— that help children begin to interpret and explain the natural world (Gomes & Fleer, 2020). Embedding these approaches in classroom practice not only enhances the didactic value of the curriculum but also aligns with the progression towards Primary Education, where such intuitive, embodied understandings can be expanded and formalized (Prieto, García Fernández & Reyes Ruiz Gallardo, 2025). This perspective can transform the curricular reflection into a practical tool for teachers, offering them concrete pathways to implement Earth Science content in developmentally appropriate ways.

Subsequently, instruction in Primary Education would advance toward phenomena that are not directly observable, whether due to their immense scale (e.g., planetary movements and their implications), their microscopic dimensions (e.g., the crystalline structures of minerals), or their occurrence over temporal scales beyond immediate human experience (e.g., the formation of a mountain range). The cognitive challenges inherent in these topics underscore the necessity of employing precursor models from the earliest stages of education (Mateo & Sáez-Bondía, 2022; Mateo, Sáez-Bondía, Martín-García & Fernández, 2023; García-Rodeja, Rodríguez-Rouco, Lorenzo-Flores & Sesto-Varela, 2023). These models are conceived as preliminary frameworks that facilitate the later construction of more sophisticated scientific models, maintaining compatibility with them while acknowledging their inherent limitations.

This early exposure to geological materials and processes helps build an educational foundation for becoming informed citizens who respect and care for the planet. To achieve this goal, education faculties and departments bear a significant responsibility in training future early childhood teachers in ES. This training will enable them to bring a comprehensive understanding of our planet into the classroom, focusing on both biotic and abiotic elements and processes to achieve the SDGs with adequate scientific rigor, and ultimately contributing to building a sustainable society.

An additional consideration emerges from the observation that early science education tends to emphasize biotic elements —such as animals and plants— while often neglecting the abiotic components of the natural world. This imbalance reflects a broader issue in science education, where dynamic, living entities are more readily included in teaching practices than static geological features, potentially due to the way human cognition favors movement and agency in perception (Bjorklund, 2022). However, this bias can lead to a fragmented understanding of the environment and reinforce the underrepresentation of Earth Sciences in the curriculum. Addressing this requires intentional curricular strategies that ensure both biotic and abiotic elements are meaningfully integrated into classroom practices. Without such efforts, the educational system risks perpetuating what has been termed the *"vicious cycle"* of Earth Science education (Orion, 2017), in which the marginalization of geoscientific content in early years education continues to manifest throughout later educational stages and into adulthood. A more holistic pedagogical framework —supported by clear references and didactic resources—can help overcome this issue by broadening children's environmental awareness and fostering a balanced scientific worldview from an early age.

5. Conclusions

The present work offers a substantive contribution to the field of Science Education by critically examining the representation of Earth Science-related content in the current Early Childhood Education curriculum, under the lens of the recent legislative framework. The analysis bridges a significant gap in the literature by contextualizing these curricular elements within Pedrinaci's theoretical contributions on the selection and didactic treatment of geological content oriented toward sustainability. As such, the findings not only enable a reflective evaluation of the curriculum but also underscore the need for a more robust and coherent integration of Earth Science literacy at the foundational stages of education.

Moreover, this study provides a significant contribution through its detailed analysis of the basic knowledge areas using the key ideas proposed by Pedrinaci et al. (2013), which are aligned with the Earth Science Literacy Principles. This analytical framework —unprecedented, to our knowledge, in studies of the early childhood stage within the LOMLOE curriculum or in the international context— represents an innovative approach to evaluating the presence of Earth Science in education.

ES, as part of scientific content, are crucial for understanding the processes occurring in our environment, and thus, should be incorporated from the earliest educational stages. The results of the curricular analysis of Royal Decree 95/2022 indicate that these contents could be included in the classroom. The data show that nearly all the KI for teaching ES proposed by Pedrinaci et al. (2013) could begin to be addressed at this stage. In the first cycle, the curriculum broadly refers to science, allowing for the inclusion of ES-related content. In the second cycle, references are more specific, particularly highlighting the presence of basic knowledge related to KI closely linked to the Sustainable Development Goals (SDGs) and scientific work.

However, it is important to highlight that, despite the ample scope for including ES content at the Early Childhood Education stage —especially compared to previous regulations (García-Yelo et al., 2022)— the general nature of the curriculum's references to science, and their lesser specificity regarding ES, means that the curriculum could potentially focus solely on biological elements and processes. Consequently, the curriculum's wording leaves the responsibility to the teacher to approach it from an ES perspective in such cases. Therefore, education faculties play a crucial role in training early childhood teachers, ensuring they recognize the importance of ES at this stage and are competent to address it appropriately. In this context, a future line of work under the current regulatory framework is to evaluate in the professional competence of early childhood teachers in incorporating ES into the curriculum, to assess the current situation, and to promote evidence-based improvements in training.

This study presents an analysis of Royal Decree 95/2022, which applies at the national level. However, the specific implementation of this curriculum is subject to the publication of official decrees that regulate these teachings in each autonomous community. As a result, there may be variations that could ultimately alter the treatment of ES in Early Childhood Education depending on the region. Therefore, analysing the different regional decrees is also established as a future line of work.

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References

Achurra, A., Berreteaga, A., & Zamalloa, T. (2023). La desnaturalización de las Ciencias de la Tierra en el currículo LOMCE de Educación Primaria: un análisis curricular desde la perspectiva de la práctica científica. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 20(1), 1303-1303. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2023.v20.i1.1303

Almeida, A., García Fernández, B., & Rodrigues, I. (2020). Perceptions of pre-service teachers on seismic risk and their implications for science education: A comparative study between Spain and Portugal. *Journal of Risk Research,* 23(6), 762-780. https://doi.org/10.1080/13669877.2019.1617335

Almeida, A., Prieto, I., & García Fernández, B. (2025). Biodiversity vs. geodiversity in landscape appreciation: what do Portuguese and Spanish pre-service teachers value?. *Landscape Research,* 1-20. https://doi.org/10.1080/01426397.2025.2505022

Bjorklund, D.F. (2022). *Children' s thinking: Cognitive development and individual differences.* Sage publications.

Bruckermann, T., Fiedler, D., & Harms, U. (2021). Identifying precursory concepts in evolution during early childhood–a systematic literature review. *Studies in Science Education*, 57(1), 85-127. https://doi.org/10.1080/03057267.2020.1792678

Cruz-Guzmán, M., Puig, M., & García-Carmona, A. (2020). ¿Qué tipos de actividades diseñan e implementan en el aula futuros docentes de Educación Infantil cuando enseñan ciencia mediante rincones de trabajo? *Enseñanza de las Ciencias. Revista de investigación y experiencias didácticas*, 38(1), 27-45. https://doi.org/10.5565/rev/ensciencias.2698

Early, D.M., Iruka, I.U., Ritchie, S., Barbarin, O.A., Winn, D.M.C., Crawford, G.M. et al. (2010). How do pre-kindergarteners spend their time? Gender, ethnicity, and income as predictors of experiences in pre-kindergarten classrooms. *Early Childhood Research Quarterly*, 25(2), 177-193. https://doi.org/10.1016/j.ecres q.2009.10.003

Elkin-Postila, T. (2022). Stories of water: preschool children's engagement with water purification. *Cultural Studies of Science Education*, 17(2), 277-299. https://doi.org/10.1007/s11422-021-10075-3

Fernández, F. (2002). El análisis de contenido como ayuda metodológica para la investigación. *Revista de Ciencias Sociales*, 2(96), 35-53.

Field, A. (2024). *Discovering Statistics using SPSS*. SAGE publications.

French, L. (2004). Science as the center of a coherent, integrated early childhood curriculum. *Early Childhood Research Quarterly*, 19, 138-149. https://doi.org/10.1016/j.ecresq.2004.01.004

Garbett, D. (2003). Science education in early childhood teacher education: Putting forward a case to enhance student teachers' confidence and competence. *Research in Science Education,* 33*,* 467-481. https://doi.org/10.1023/B:RISE.0000005251.20085.62

García Fernández, B., & Sánchez Vizcaíno, J. (2016). Estrategias didácticas para enseñar a través del entorno. In A. Mateos Jiménez & A. Manzanares Moya (coords.), *Mejores maestros, mejores educadores: innovación y propuestas en Educación* (pp. 287-314). Aljibe.

García-Marigómez, C., Ortega-Quevedo, V., & Gil-Puente, C. (2023). Teaching and learning geology as a way to develop thinking and encourage positive attitudes towards science. *ReiDocrea*, 12(19), 242-260. https://doi.org/10.30827/Digibug.82318

García-Rodeja, I., Rodríguez-Rouco, E.V., Lorenzo-Flores, M., & Sesto-Varela, V. (2023). Construyendo modelos precursores sobre la flotabilidad de objetos macizos a los seis años. *Enseñanza de las Ciencias*, 41(2), 137-154. https://doi.org/10.5565/rev/ensciencias.5718

García-Yelo, B.A., Buitrago, E.G., & García, E.G. (2022). El estado de la Geología en el currículo. Una situación preocupante. *Supervisión,* 21, 65(65). https://doi.org/10.52149/Sp21/65.3

Gomes, J., & Fleer, M. (2020). Is science really everywhere? Teachers' perspectives on science learning possibilities in the preschool environment. *Research in Science Education*, 50(5), 1961-1989.

Green, C.J. (2015). Toward young children as active researchers: A critical review of the methodologies and methods in early childhood environmental education. *The Journal of Environmental Education*, 46(4), 207-229. https://doi.org/10.1080/00958964.2015.1050345

Greenfield, D., Jirout, J., Dominguez, X., Greenberg, A., Maier, M., & Fuccillo, J. (2009). Science in the preschool cassroom: A programmatic research agenda to improve science readiness. *Early Education & Development,* 20*,* 238-264. https://doi.org/10.1080/10409280802595441

Guo, Y., Wang, S., Hall, A.H., & Busch, J. (2016). The effects of science instruction on young children's vocabulary learning: A research synthesis. *Early Childhood Education Journal,* 44(4), 359-367. https://doi.org/10.1007/s1064 3-015-0721-6

Iglesias, J.D., & Calonge, M.A. (2018). Estudio de la presencia de la Geología en currículos oficiales autonómicos de Educación Primaria. *Enseñanza de las Ciencias de la Tierra*, 26(2), 154-154.

Inoue, M., Elliott, S., Mitsuhashi, M., & Kido, H. (2019). Nature-based early childhood activities as environmental education?: A review of Japanese and Australian perspectives. *Japanese Journal of Environmental Education*, 28(4), 21-28. https://doi.org/10.5647/jsoee.28.4_21

Islas, D.S.C. (2020). Análisis de contenido analógico: una aplicación de la hermenéutica analógica para el análisis de contenido curricular. *Revista Latinoamericana de Metodología de las Ciencias Sociales: Relmecs*, 10(1), 7. https://doi.org/10.24215/18537863e071

Kalogiannakis, M., Rekoumi, C., Antipa, E., & Poulou, V. (2010). Preschool education and geology within the scope of environmental education: the case of a teaching intervention at kindergarten. En *Proceedings of the 3rd World Conference on Science and Technology Education (ICASE 2010), Innovation in Science and Technology Education: Research, Policy, Practice* (159-163). Tartu, Estonia.

Korkmaz, B.C., & Altinsoy, M.G. (2023). The Position and Importance of Geology Education in the Schools. *The Journal of Limitless Education and Research*, 8(2), 158-170. https://doi.org/10.29250/sead.1308354

Lacreu, H. (1999). Las geociencias en la alfabetización científica. In Kaufman, M., & Fumagalli, L. (Comp.), *Enseñar ciencias naturales* (239-270). *Buenos Aires: Paidós.*

Marco-Stiefel, B. (2004). Alfabetización científica: un puente entre la ciencia escolar y las fronteras científicas. *Cultura y Educación,* 16(3), 273-287. https://doi.org/10.1174/1135640042360906

Mateo, E., & Sáez-Bondía, M.J. (2022). Experimentar con minerales en Educación Infantil: evaluación de un espacio de Ciencia de libre elección. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias,* 19(2). https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2022.v19.i2.2801

Mateo, E., Sáez-Bondía, M.J., Martín-García, J., & Fernández, S. (2023). Algunos principios de diseño de espacios de ciencias de libre elección monotemáticos. *Didáctica de las ciencias experimentales y sociales*, 45, 35-52. https://doi.org/10.7203/dces.45.27360

Medina, M.Á.N., & Galván, J.J.M. (2021). La nueva Ley de Educación (LOMLOE) ante los Objetivos de Desarrollo Sostenible de la Agenda 2030 y el reto de la COVID-19. *Avances en supervisión educativa*, 35. https://doi.org/10.23824/ase.v0i35.709

Morote, Á.F., & Olcina-Cantos, J. (2023). Cambio climático y educación: una revisión de la documentación oficial. *Documents d'anàlisi geogràfica,* 69(1), 107-134. https://doi.org/10.5565/rev/dag.749

National Research Council (2012). *A framework for K-12 science education.* Washington, DC: National Academies Press.

NGSS Lead States (2013). *Next generation science standards: For states, by states.* Washington, DC: The National Academies Press.

National Science Foundation (2009). *Earth Science Literacy Principles*. Available at: http://www.earthscienceliteracy.org/

Nxumalo, F. (2017). Geotheorizing mountain–child relations within anthropogenic inheritances. *Children's Geographies*, 15(5), 558-569. https://doi.org/10.1080/14733285.2017.1291909

Oppermann, E., Brunner, M., & Anders, Y. (2019). The interplay between preschool teachers' science self-efficacy beliefs, their teaching practices, and girls' and boys' early science motivation. *Learning and Individual Differences,* 70(1), 86-99. https://doi.org/10.1016/j.lindi f.2019.01.006

Organic Law 3/2020, of December 29, which amends Organic Law 2/2006, of May 3, on Education. BOE, 340, of December 30, 122868-122953.

Orion, N. (2017). The relevance of earth science for informed citizenship: Its potential and fulfillment. In Liete, L., Dourado, L., & Morado, S. (Eds.). *Contextualizing teaching to improving learning* (.41-56). New York: Nova Science Publishers.

Pedrinaci, E. (2012). Alfabetización en Ciencias de la Tierra, una propuesta necesaria. *Enseñanza de las Ciencias de la Tierra*, 20(2), 133-133.

Pedrinaci, E., Alcalde, S., Alfaro, P., Almodóvar, G.R.,Barrera, J.L., Belmonte, A. et al. (2013). Alfabetización en ciencias de la Tierra. *Enseñanza de las Ciencias de la Tierra,* 21(2), 117-129.

Pedrinaci, E. (2016). Qué debe saber todo ciudadano acerca del planeta en que habita. *Alambique Didáctica de las Ciencias Experimentales*, 83, 7-12.

Prieto, I., García Fernández, B., & Reyes Ruiz-Gallardo, J. (2025). Las ciencias de la Tierra en Educación Primaria: un análisis del currículo de la LOMLOE. *Enseñanza de las Ciencias,* 43(2), 23-40. https://doi.org/10.5565/rev/ensciencias.6221

Prieto, I., Mateos, A., & García Fernández, B. (2024). Dinosaurios y educación: Un vínculo necesario. El aprovechamiento didáctico del patrimonio paleontológico de Cuenca (España) en la formación de maestros. In *Educación para la ciudadanía activa: Innovación y prácticas emergentes en los contextos educativos* (pp. 217-229). Dykinson. https://doi.org/10.14679/3629

Raviv, A., & Dadon, M. (2021). Teaching Astronomy in Kindergarten: Children's Perceptions and Projects. *Athens Journal of Education*, 8(3), 305-327. https://doi.org/10.30958/aje.8-3-4

Royal Decree 95/2022, of February 1. *Establishing the structure and minimum teachings of Early Childhood Education*. BOE, 28, of February 2.

Stemler, S. (2000). An overview of content analysis. *Practical assessment, research, and evaluation*, 7(1), 17.

Twomey, M., O'Siorain, C.A., Shevlin, M., & McGuckin, C. (2021). Dinosaurs in the Classroom: Using the Creative Arts to Engage Young Children with Autism. *REACH: Journal of Inclusive Education in Ireland*, 34(1).

van Den Broek, P., Kendeou, P., Kremer, K., Lynch, J., Butler, J., White, M.J. et al. (2005). Assessment of comprehension abilities in young children. In *Children's Reading Comprehension and Assessment* (125-148). Routledge.

van Vuuren, E.J. (2023). Early Childhood in the Era of Post-humanism: Lending an Ear to Nature. *Journal of Curriculum Studies Research*, 5(1), 171-180. https://doi.org/10.46303/jcsr.2023.13

Wandersee, J.H., & Schussler, E.E. (1999). Preventing plant blindness. *The American biology teacher*, 61(2), 82-86.

Weldemariam, K., Boyd, D., Hirst, N., Sageidet, B.M., Browder, J.K., Grogan, L. et al. (2017). A critical analysis of concepts associated with sustainability in early childhood curriculum frameworks across five national contexts. *International Journal of Early Childhood*, 49, 333-351. https://doi.org/10.1007/s13158-017-0202-8

Wolff, L.A., Skarstein, T.H., & Skarstein, F. (2020). The Mission of Early Childhood Education in the Anthropocene. *Education Sciences*, 10(2), 27. https://doi.org/10.3390/educsci10020027

Zhang, Y., Wang, W., Wang, Z., Gao, M., Zhu, L., & Song, J. (2021). Green building design based on solar energy utilization: Take a kindergarten competition design as an example. *Energy Reports*, 7, 1297-1307. https://doi.org/10.1016/j.egyr.2021.09.134

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