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EDITED BY
Kwok Kuen Tsang,
The Education University of Hong Kong, Hong Kong SAR, China

REVIEWED BY
Enrique H. Riquelme,
Temuco Catholic University, Chile
Ririn Ambarini,
Universitas PGRI Semarang, Indonesia

*CORRESPONDENCE
Florencia Natalia Praderio Gaias
✉ florencianatalia.praderio@um.es

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The influence of emotions on science teaching: a case study with three early childhood education teachers

Florencia Natalia Praderio Gaias[1]*, Melina Furman[2,3], Mariana Luzuriaga[2,3], Emilio Costillo Borrego[4] and G. Enrique Ayuso Fernández[1]

[1]Universidad de Murcia, Murcia, Spain, [2]Universidad de San Andrés, Victoria, Argentina, [3]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina, [4]Universidad de Extremadura, Badajoz, Spain

Teaching science in early childhood education (ECE) is crucial for fostering essential scientific thinking skills, which are vital for young learners' development and formative trajectories. While this educational level presents exciting opportunities for integrating science teaching, it also poses challenges related to teachers' cognitive, pedagogical, and emotional constraints. Recognizing the pivotal role of teachers' emotions in shaping their practices, we aim to specifically examine the influence of teachers' emotions on science teaching in ECE, an area that remains underresearched. We conducted a multiple case study involving three ECE teachers in La Plata, Argentina, who demonstrated a strong interest in improving their pedagogical practices despite acknowledging their difficulties and insecurities in teaching science. We explored their emotions and how they relate to science lesson planning and implementation through surveys, in-depth interviews, and observations. Data collection was designed in three stages: pre-active, interactive, and post-active teaching. First, we surveyed the range of negative and positive emotions that teachers experienced toward sciences, rooted in their personal and formative prior experiences, and examined how these emotions influenced their planning (pre-active stage). Subsequently, we investigated the emotions associated with science teaching in the interactive stage and recorded classroom observations to document how they implemented their plans. Finally, we conducted in-depth interviews with the teachers while they watched the recorded class videos, allowing them to reflect on their decision-making and implementation characteristics (post-active stage). Our findings reveal a dichotomy: negative emotions derived from past experiences reduce engagement, while positive emotions enhance motivation and enrich the learning environment. Negative emotions arising from the implementation of science activities in real classroom contexts may lead to canceled classes, whereas positive emotions foster persistence and optimism. We discuss the significance of emotional awareness in teaching practices, emphasizing the importance of understanding and managing negative emotions through teacher training and professional development programs. This approach can enhance teacher confidence and satisfaction, ultimately contributing to improved early childhood science education.

KEYWORDS

teacher emotions, science education, childhood education, lesson planning, teaching practices

1 Introduction

From an early age, children exhibit a natural curiosity and eagerness to explore the world around them, along with rudimentary scientific thinking skills such as intuitive experimentation, prediction, pattern recognition, and drawing conclusions from evidence (Furman, 2016). However, research indicates that these skills do not develop spontaneously; rather, they must be nurtured, expanded upon, and made conscious to evolve into more structured knowledge through intentional experiences and instruction (Haldón Lahilla et al., 2022; Klahr et al., 2011; Pedreira and Márquez, 2019). When this nurturing occurs during the early years of schooling, evidence suggests that it leads to improved learning outcomes in later educational stages (Ford et al., 2023).

Consequently, there is a growing consensus on the importance of promoting science instruction in early childhood education (ECE) to cultivate students' curiosity, initiate the development of scientific thinking skills, and enhance academic readiness, thereby contributing to more successful educational trajectories (Mateo and Sáez-Bondía, 2022). In Buenos Aires, Argentina, the setting for this study, national and jurisdictional curriculum standards for ECE incorporate science as a subject area, aiming to nurture curious, observant, autonomous, creative, and cooperative children who become engaged citizens (Ministerio de Educación Argentina, 2012; Dirección General de Cultura y Educación de la Provincia de Buenos Aires, 2022).

However, similar to other countries, integrating science instruction in ECE remains a challenge, as students generally have limited opportunities to learn science at this level (Saçkes, 2014). The literature suggests that teachers often avoid teaching science because they prioritize other subject areas, perceive it as too difficult, or feel insecure about their own understanding of natural phenomena. Consequently, the educational potential of scientific activities is not always maximized, often due to teachers' shortcomings in content knowledge and preparation in effective science teaching approaches (Cohen and Emmons, 2017; Lee et al., 2024). In other words, ECE teachers' science pedagogical content knowledge (PCK) is a significant area of concern and improvement (Nilsson and Elm, 2017).

PCK is a construct originally coined by Shulman (1986). It refers to teachers' ability to master content and implement effective teaching strategies tailored to the content and students' characteristics, including anticipating methods for making the content understandable to learners, addressing student difficulties and misconceptions, and adeptly assessing learning outcomes. Notably, recent research on PCK has emphasized the importance of considering teachers' emotions as a fundamental element of this construct, arguing that emotions profoundly affect decision-making and teaching practices (Garritz, 2010; Zembylas, 2007). This perspective is further reinforced by Shulman (2012) reflection, in which he acknowledged the omission of the affective dimension as a limitation of his initial formulations, advocating for the incorporation of emotions as an essential component of PCK. Thus, integrating emotions into PCK suggests a more holistic approach to the educational process, recognizing that teachers are not merely transmitters and managers of knowledge but also emotional beings whose perceptions and feelings significantly influence their pedagogical practices.

Professional development is essential for teachers to improve their PCK and, consequently, to teach science effectively to young learners. PCK is a concept that refers to a teacher's ability to transform content knowledge into meaningful learning experiences for students. This type of knowledge is essential, as it not only involves knowing the subject matter being taught but also understanding how to teach it in a way that students can comprehend and apply (Díaz and Cofré, 2014; Talanquer, 2018; Shulman, 2019). Research has shown that teachers with strong PCK are able to facilitate deeper and more meaningful learning for their students, which is particularly critical in science education, where concepts can be abstract and complex (Oliva and Fuentes-Guerra, 2017; Mendoza et al., 2016).

Continuous training and professional development also encourage critical reflection on pedagogical practices. Teachers who participate in professional development programs have the opportunity to identify and address gaps in their PCK, which can lead to a change in their teaching conceptions (Patiño, 2023; Maldonado and Balderas, 2023). This reflective process is crucial for the continuous improvement of teaching practice and for adapting to the changing needs of students in the classroom (Marzábal et al., 2016).

In conclusion, professional development is essential for teachers to improve their PCK and teach science effectively. Through continuous training and critical reflection on practice, educators can strengthen their ability to provide quality education that fosters meaningful learning in children.

Essentially, emotions can be defined as reactions to environmental information shaped by subjective evaluations, prior knowledge, and beliefs. They can be triggered by both present events and memories or anticipations, with the relevance of the stimulus determining the emergence of an emotion (Bisquerra, 2000). Emotions can be perceived as positive or negative, which refers to the emotional valence and affective tone of an experience or situation and vary according to their "degree of activation," that is, the intensity or energy that a particular emotional experience arouses in individuals (Agen and Ezquerra, 2021; Sanchez-Martín et al., 2018).

From a constructivist perspective, emotions are not merely biological reactions but are shaped through interactions between individuals and their sociocultural environment. Emotions are constructed based on the subjective interpretation of experiences influenced by prior knowledge, beliefs, and values. Additionally, from a cultural perspective, emotions are shaped by social norms, expectations, and educational practices, meaning that the educational context and interactions within it play a crucial role in how teachers experience and express their emotions (Sibia, 2013).

Applied to science teaching, this means that teachers' emotions are not just individual responses but also the result of their interactions with students, past experiences, and the expectations of the educational community. Thus, emotions reflect the teacher's personal history and the cultural framework they teach (Zembylas, 2007). To fully analyze emotions in this context, it is necessary to consider both their biological dimensions and their socially constructed nature (Tan, 2013).

The emotional dimension in teaching and learning is not new and has been addressed from multiple perspectives and in relation to various educational aspects. In particular, it is worth highlighting studies that have pointed out the essential role that emotions play in teaching (Agen and Ezquerra, 2021; Dávila et al., 2021). For one, there is evidence that teachers' emotions, deeply rooted in their previous formative trajectories and experiences, influence their personal beliefs and expectations toward teaching, as well as their confidence in their instructional skills and classroom management practices to promote

student learning [commonly referred to as "self-efficacy," Bandura (1977)].

For example, Bravo Lucas et al. (2022) explored pre-service teachers' emotions toward science education as they recalled their formative trajectories. They found that, in general, primary-level science education experiences were associated with positive emotions, while in secondary school, they were also positive toward biology and geology lessons but negative toward physics and chemistry.

Moreover, these recollections of emotions that teachers experienced in relation to science during their schooling were transferred to the emotions they predicted they would feel when teaching these subjects, showing a relationship with other affective dimensions. Similarly, studies conducted at various Spanish universities offer an insightful view of how the emotions experienced by primary school teachers in training during their own schooling influence their feelings and expectations regarding teaching science (Brígido et al., 2013). This is of special significance, considering that when teachers have positive attitudes and emotions toward science, it significantly enhances their students' scientific learning opportunities (Fleer et al., 2014; Ford et al., 2023).

On the other hand, studies show that the emotions teachers experience during their science lessons impact their performance, curricular decisions, and ability to adapt and implement their teaching practices (Dávila et al., 2015; Cañada et al., 2018). In this regard, Agen and Ezquerra (2021) and Dávila et al. (2021) discuss that one of the greatest challenges for ECE teachers in science lessons lies in managing the emotions that arise when enacting them, which can be affected by previous educational experiences and generate insecurities impacting their development and professional practice. Furthermore, teachers' needs and expectations generate emotions that affect the perception and evaluation of their practices (Hernández-Barco et al., 2021; Davidson et al., 2020). Thus, these authors highlight that, in the educational field, emotions influence more than cognitive aspects directly.

Given the significant role of teachers' emotions in shaping their pedagogical practices, it is crucial to explore how scientific practices are effectively integrated into ECE to enhance children's learning. Scientific practices such as inquiry, modeling, and argumentation have been shown to foster active learning and a deeper understanding of concepts.

For example, the project "What's That Sound Inside Your Body?" allowed children to explore the heart through inquiry, modeling, and argumentation, resulting in complex models of the human body and improved systems thinking (Gil et al., 2021). In another study, Bargiela et al. (2017) found that inquiry was the most prevalent practice in Galicia's early childhood curriculum. However, it noted its limited inclusion in teacher training programs, highlighting the need for better integration.

Villaseñor and Robles (2020) explored the circulatory system through modeling, enabling students to build models connecting different organs, enhancing conceptual learning and collaboration. Lastly, Morales and Alsina (2021) emphasized the importance of argumentation in early childhood mathematics education, showing how it develops critical thinking and decision-making skills.

These examples underscore the importance of integrating scientific practices in early education to promote deeper conceptual understanding and essential skill development.

Within this context, in this study, we aim to explore the emotions that ECE teachers have toward science instruction and examine how these emotions, as perceived by the teachers themselves, influence their planning and implementation of science lessons. To achieve this, we designed a qualitative multiple-case study involving three ECE teachers from a school in La Plata, Argentina.

Specifically, the research questions we addressed are:

- What emotions do teachers associate with their previous experiences with learning science?
- What are the emotions that teachers associate with their science teaching practices?
- What relationships do teachers establish between their emotions and their decisions when planning and implementing science lessons?

2 Materials and methods

2.1 Design

This study is framed within a qualitative design, employing a multiple case study approach (Yin, 2018), to identify the emotions that ECE teachers associate with their prior science formative experiences and teaching practices and how these emotions influence their decisions during the planning and implementation of science lessons. The study involved three teachers from an ECE center in the city of La Plata, Argentina, working with children aged 3–5 years.

The research was conducted in three phases, following Jackson (2010) framework, which posits that the teaching process involves preactive, interactive, and postactive stages. The preactive stage occurs before actual teaching and encompasses teachers' prior knowledge, experiences, emotions, lesson planning, preparation, and design. The interactive stage occurs during teaching, where teachers actively interact with students, present content, and facilitate learning. Lastly, the postactive stage occurs after teaching and involves activities such as evaluation, reflection on the delivered instruction, and adjustments for future sessions.

Different data collection techniques were combined in the successive research phases. In the preactive stage, a survey was administered to identify teachers' experiences and emotions toward science when they were students, as well as questions about their current emotions toward teaching and perceived self-efficacy. Additionally, a documentary analysis of the teachers' lesson plans was conducted to understand the content and activities they propose for their science classes. This was complemented by semi-structured interviews to explore the rationale behind their decision-making and the influence of emotions on science learning and teaching.

In the interactive phase, class observations and recordings were carried out to analyze the implementation of the lesson plans and how emotions influenced real-time pedagogical decisions. In the postactive stage, semi-structured interviews were conducted with the teachers, and the videos from the interactive phase were reviewed to discuss their emotions at specific moments. This allowed for an in-depth reflection on the relationship between emotions and pedagogical practices, including how these emotions influence potential adjustments in teaching strategies.

Below is a detailed description of the study context and participants, data collection instruments, and data analysis strategies.

2.2 Participants and context

The research was conducted at an ECE Center located in the city of La Plata, Argentina. It was inaugurated in 2018 and serves a group of 53 children aged between 3 and 5 years, predominantly from working-class families. A distinctive feature of this educational community is that in most families, at least one parent holds a professional role in the local City Hall. The school's facilities are designed to foster comprehensive development of the students, including classrooms specifically adapted for different age groups, a computer room, a library, gender-segregated restrooms, a multi-purpose room for various activities, outdoor recreational spaces with a school garden, and essential administrative areas. The center operates from 7:45 am to 3:45 pm, supported by a multidisciplinary team that includes the principal, three teachers, pedagogical support staff (2 people), administrative personnel (one person), specialists in various disciplines (Physical Education, Computing, and Music), and a maintenance worker.

The selection of these participants was based on the willingness of the institution to engage in the study, driven by their recognition of their own difficulties and insecurities in teaching science. This context offered a valuable opportunity to deeply analyze teachers' emotions regarding science teaching in a specific educational environment. All educators demonstrated a strong interest in reflecting on their pedagogical practices and improving their confidence in teaching science despite their perceived challenges.

All three teachers in the educational center participated in the study: Celina, in charge of the three-year-old group; Gina, in charge of the four-year-old group; and Maite, in charge of the five-year-old group. All teachers were 30 years old and had between 4 and 9 years of experience in teaching in ECE. While Celina had experience teaching all three age groups, Maite led a five-year-old class for the first time, and Gina had previously worked as an assistant. Over the last 5 years, all teachers have participated in different professional development programs, but only Maite has recently completed a course specifically on the natural and social environment. Table 1 below summarizes the demographic characteristics of the teachers (their names have been changed to preserve their identity, privacy, and confidentiality).

It is worth noting that the openness and support from the institution, along with the cooperation of the participating teachers, were crucial for conducting the study. A relationship of respect and trust was established between the teachers and researchers, which proved vital for obtaining access and deep and authentic insights into the satisfactions and challenges faced by the teachers when planning and implementing their science lessons. This facilitated a richer understanding of how emotions influence pedagogical practice.

2.3 Instruments of data collection

As previously mentioned, the study was conducted in three phases using a combination of data collection techniques. **Table 2** below presents each phase and the techniques employed in relation to the research questions. The corresponding instruments for each technique are described in more detail below.

2.3.1 Instrument A: survey on emotions in science teaching

In the first phase, during the context of annual planning at the beginning of the academic year, a survey with closed-ended and multiple-choice questions was administered. This instrument, adapted from Borrachero et al. (2011), was designed to investigate the emotions, states of mind, feelings, and attitudes that teachers associate with their experiences learning science throughout their educational trajectory, from primary school to teacher training. Teachers were asked to indicate at which educational level and in which area of science knowledge (biology, chemistry, or physics) they experienced specific emotions, as detailed in **Table 3**.

In the second section of the survey, teachers were asked about the emotions they associate with teaching different science content in ECE and how prepared they feel to carry out various teaching-related tasks, both generally and specifically in science. An adaptation of Bandura's perceived self-efficacy scale (1977) was used for this purpose (See **Table 3**).

The survey was developed and validated through research conducted at the University of Extremadura with students from the Faculty of Education (Borrachero et al., 2011; Brígido et al., 2013; Costillo et al., 2013). The construction of the questionnaire followed the steps recommended by Marín Ibáñez and Pérez Serrano (1985): determining the necessary type of information, selecting the most relevant aspects, deciding on the most appropriate format, creating an initial draft, subjecting it to expert critique, testing it with an experimental group, and refining it before finalizing the procedures for its administration. The validation process involved expert review and the application of Cronbach's alpha coefficient, which yielded values above 0.8 across all scales, ensuring high internal consistency. This instrument effectively measures emotions related to science teaching, providing a solid framework for this study.

2.3.2 Instrument B: document analysis of lesson plans

During the preactive phase, a document analysis of the teachers' science lesson plans was conducted using a specific protocol

TABLE 1 Demographics of participating teachers.

Name	Age	Gender	Educational background	Teaching experience in ECE	Age group
Celina	30	Female	Higher education teacher training	9 years	3 years
Gina	30	Female	Higher education teacher training	4 years	4 years
Maite	30	Female	Higher education teacher training	7 years	5 years

TABLE 2 Stages, techniques, and data collection instruments in relation to the research questions.

Phase	Techniques and instruments	Research questions
Pre-active	Survey. Closed-ended and multiple choice questionnaire on teachers' emotions in prior formative experiences (Instrument A, section 1).	What are the emotions that teachers associate with their previous experiences with learning science?
Annual planning session at the beginning of the academic year.	Survey. Closed-ended and multiple choice questionnaire on teachers' emotions toward science teaching and self-efficacy (Instrument A, section 2).	What are the emotions that teachers associate with their science teaching practices?
	Documentary analysis of science lesson plans (Instrument B).	
Interactive	Classroom observations and video recordings of science lessons.	What relationships do teachers establish between their emotions and their decisions when planning and implementing science lessons?
Implementation of the science lesson plans during the academic year		
Post-active	Semi-structured interviews based on science lesson plans and video recordings (Instrument C).	
After the implementation of the planned science lessons.		

(Instrument B). This analysis focused on identifying the content (including conceptual, scientific, and attitudinal content) as well as the types of activities proposed. The objective was to gather additional information to further investigate teachers' decision-making when planning and implementing science lessons, particularly the potential influence of emotions on these processes.

The protocol used for document analysis was validated through expert review in science education, ensuring it adequately covered the three types of proposed content (conceptual, scientific skills, and attitudinal). In addition, pilot tests were conducted with a group of teachers to adjust the analysis criteria and ensure consistency in coding the lesson plans.

2.3.3 Instrument C: semi-structured interviews

In the post-active phase, semi-structured interviews were conducted with the participating teachers. These interviews were designed to delve into the decision-making processes in lesson planning and teaching and how these processes were linked to their emotions. Additionally, videos from the interactive phase were reviewed with the teachers to inquire about their emotional states at specific moments. The interviews provided additional context to the observations made during the interactive phase and allowed teachers to reflect on their experiences. Some of the guiding questions included in the interview script were:

- Can you give me an example of a science class (during your interventions, students' questions, behaviors, etc.) that made you feel very positive? Why do you think you felt that way?
- When you feel positive, do certain aspects of your classes improve (relationship with students, the questions you ask, interventions, etc.)? Can you provide an example?
- Do you recall any moment in your science classes (during your interventions, students' questions, behaviors) that made you feel negative? Why do you think you felt that way?
- When you feel negative, do any aspects of your classes worsen? Can you give me an example?

The interview script was developed and validated through a pilot test with a small group of teachers to assess the clarity of the questions and their ability to gather detailed information on emotions and pedagogical decision-making. Adjustments were made based on the feedback from this pilot, and the final script was reviewed by experts in qualitative research to ensure it covered the most relevant aspects of the study.

2.3.4 Instrument D: observation guide on teachers' emotions

In the interactive phase, an observation guide was used to systematically record the emotions expressed by teachers during science lessons. This guide focused on capturing facial expressions (e.g., smiles, frowns, or signs of tension), tone of voice (whether soft, firm, or raised), and body language (e.g., open or closed postures, supportive gestures, crossed arms). Special attention was given to how the teachers interacted with the children and responded to questions, behaviors, or conflicts. Research by Sutton and Wheatley (2003) suggests that body language and tone of voice are key 11 manifestations of teachers' emotions, which can directly influence classroom dynamics and student learning. Additionally, the guide aimed to capture how teachers managed the classroom, especially during moments of tension or at the end of the session, to identify signs of energy, calm, or fatigue. This aspect was based on Hagenauer and Volet's (2014) work on the influence of emotional management on teacher performance and classroom environment.

During the interactive stage, classroom observations were conducted and recorded to analyze the real-time contextualized implementation of lesson plans. A total of 5 classes (an average of 100 min in total) per teacher were observed. The field notes and recordings from these observations were used as inputs during the subsequent semi-structured interviews to facilitate the teachers' reflections on their emotions at different moments of the class and how they account for their decisions and courses of action.

2.4 Data analysis

To identify teachers' emotions toward science teaching and the relationships they establish between these emotions and decision-making in the planning and delivery of lessons, a thematic content

TABLE 3 Instrument A.

Section	Question	Options for response
1	What emotions did you feel in Primary, Secondary and Teacher Training education when you were taught and learned the contents of Biology, Chemistry and Physics?	Irritability, pride, fear, tranquility, tension, pleasure, concern, sympathy, hatred, anxiety, happiness, despair, nervousness, satisfaction, impotence, fun, frustration, boredom, sadness, curiosity, pessimism, joy.
2	What emotions do you feel or believe you would feel if you had to teach the contents of Biology, Chemistry and Physics?	Irritability, pride, fear, tranquility, tension, pleasure, concern, sympathy, hatred, anxiety, happiness, despair, nervousness, satisfaction, impotence, fun, frustration, boredom, sadness, curiosity, pessimism, joy.
	Self-efficacy scale: What can you do as a teacher to…? Please select an option for each statement. [e.g., "…assess students' understanding of what you have taught?" "…adjust your lessons to each student's appropriate level?" "…use different teaching and assessment strategies?"]	1. Nothing
		2. Very little
		3. Some
		4. Quite a bit
		5. A lot

TABLE 4 Main categories, subcategories, and codes.

Main category	Subcategory	Codes
Teacher emotions	Positive emotions	Pride; Tranquility; Pleasure; Sympathy; Happiness; Satisfaction; Fun; Curiosity. Negative Emotions:
	Negative emotions	Irritability; Fear; Tension; Concern; Hatred; Anxiety; Despair; Nervousness; Powerlessness; Frustration; Boredom; Sadness; Pessimism.
	Origin/triggers of emotions: (subject, object, or situation).	Prior experiences; contents to teach; activities to develop; student behavior; class interruptions by students; other teachers; families; students' interests.
Pedagogical decisions	Contents chosen and implemented.	Conceptual contents, scientific skills, attitudinal contents.
	Activities chosen and implemented.	Content exposition, problem-solving, experimental design, debates, research, and hypothesis.

analysis (Boyatzis, 1998) was conducted using surveys, lesson plan document analysis, interviews, and classroom observations. Two main dimensions were considered: first, the identification and classification of emotions, and second, the types of pedagogical decisions. Initially, all data from various sources were thoroughly reviewed, identifying key themes for each dimension through an open coding strategy. Subsequently, the data were classified using both inductive and theoretical techniques, grouping them into relevant categories.

The data analysis was conducted in three stages. First, during data collection, initial patterns such as significant words, phrases, or expressions were identified, which allowed for a preliminary interpretation and informed the design of the in-depth interview. Second, once the data were organized, an inductive and theoretical coding process was applied, grouping the information into codes that facilitated a preliminary classification. Finally, a more in-depth analysis was conducted for each case, focusing on teachers' emotions and their impact on lesson planning and teaching. The codes were reorganized into categories and subcategories, allowing for a more comprehensive interpretation.

Subsequently, a detailed analysis was carried out to identify emotions and their influence on lesson planning and teaching practices, which resulted in a recording process to develop the final categories for comparative analysis. This process was supported by Atlas.ti version 8, facilitating efficient data management and the identification of significant patterns. The resulting categories and codes are summarized in Table 4 below.

An iterative coding process was conducted to ensure the analysis's validity and reliability. Throughout this process, the researchers discussed the criteria used at each stage, achieving a level of agreement exceeding 85%.

2.5 Validity, reliability, and ethics

The validity, reliability, and ethical considerations of this research were meticulously addressed to ensure the integrity and quality of the study (Denzin and Lincoln, 2012). Validity was strengthened through careful selection and design of data collection strategies, allowing for a profound and significant exploration of the study phenomenon. The implementation of methodological triangulation, which includes the use of diverse sources, types of data, and researchers, significantly contributed to the study's validity, providing a richer and more multifaceted understanding of participants' experiences and perceptions.

To ensure reliability, special attention was paid to the consistency of findings throughout the research process. This was achieved through detailed documentation of the methods and procedures used, allowing for the study's replication. The application of standardized data coding and analysis techniques, along with peer review of the results, further reinforced the reliability of the findings.

Ethical aspects were central to this research, following the guidelines set by Denzin and Lincoln (2012). Informed consent was secured from all participants, ensuring they were fully informed about the study's purpose, the nature of their participation, and the use of the data collected. Participants' privacy and confidentiality were always protected, and their right to withdraw from the study at any point without any negative consequences was respected.

Together, these measures contribute to the study's quality and credibility and safeguard the rights and wellbeing of the participants.

3 Results

3.1 What emotions do teachers associate with their previous experiences with learning science?

First, we investigated the emotions, states of mind, feelings, and attitudes related to emotions that teachers associate with their previous educational experiences in learning science. In the surveys, all three participating teachers indicated that they generally enjoyed science during their primary, secondary, and teacher training education. For example, Celina mentioned her fascination with animals and their characteristics as a reason for enjoying the subject in primary school, as well as her positive experiences with practical activities and laboratory work during her teacher training. Similarly, Gina stated that she enjoyed science at both the primary and secondary levels because it sparked her interest, and she particularly liked attending laboratory and nutrition classes. Maite also affirmed that she enjoyed science lessons at all educational levels, attributing this to her interest in the topics covered.

However, the teachers also indicated that they did not enjoy science lessons at certain educational levels, associating them with negative emotions, mainly due to specific situations. For instance, Celina stated that the treatment from her secondary teachers, who were either too strict or impassionate, made her lose interest in the subject. On the other hand, both Gina and Maite noted that they had few learning experiences during teacher training, which in the former case also led to a loss of enjoyment and interest. Table 5 below shows the results of the initial survey conducted with teachers, indicating whether they enjoyed science lessons and the emotions they associated with biology, chemistry, and physics topics at each educational level.

Notably, the three teachers selected a limited range of emotions associated with learning sciences across different educational levels and areas of knowledge. In particular, they frequently mentioned positive emotions such as fun, pleasure, and curiosity, as well as negative ones like boredom, irritability, and impotence. However, the teachers did not choose other emotions included in the survey, such as pride, fear, tension, hatred, anxiety, happiness, and joy.

As shown in Table 5, upon further analysis of the emotions associated with each formative stage and in the areas of knowledge of biology, chemistry, and physics, we found a predominance of positive emotions in primary and biology topics. Celina associated learning biology in primary school with emotions such as "pleasure," "sympathy," and "curiosity," while Gina associated it with "fun." Conversely, Maite associated it with "irritability," which aligns with her comments regarding her preference for science but not for her teachers. Remarkably, in all cases, they only mentioned emotions related to biology at this level.

In secondary school, we identified a certain duality or mix of emotions, distinct among areas of knowledge, which, in this case, were all considered. Celina associated learning biology at this level with positive emotions ("pleasure," "sympathy," and "curiosity," as in primary) but negative ones in chemistry ("irritability," "frustration," "boredom," "pessimism") and physics ("frustration" and "boredom").

TABLE 5 Teacher survey results on enjoyment of science lessons and associated emotions by educational level and area of knowledge.

		Gina	Celina	Maite
Primary level	Did you enjoy science lessons?	Yes	Yes	Yes
	Emotions associated with biology	**Fun**	**Pleasure Sympathy Curiosity**	*Irritability*
	Emotions associated with chemistry	–	–	–
	Emotions associated with physics	–	–	–
Secondary level	Did you enjoy science lessons?	Yes	No	Yes
	Emotions associated with biology	**Pleasure** *Boredom*	**Pleasure Sympathy Curiosity**	–
	Emotions associated with chemistry	**Sympathy** *Boredom Irritability*	*Irritability Frustration Boredom Pessimism*	**Tranquility Satisfaction Curiosity**
	Emotions associated with physics	*Irritability Boredom*	*Frustration Boredom*	Curiosity
Teacher training	Did you enjoy science lessons?	No	Yes	Yes
	Emotions associated with biology	*Desperation Impotence Sadness*	**Pleasure Sympathy Curiosity**	*Worry Impotence*
	Emotions associated with chemistry	–	**Satisfaction**	–
	Emotions associated with physics	–	**Satisfaction**	–

Positive emotions are indicated in bold and negative emotions are indicated in italics.

Gina, on the other hand, stated that all areas bored her. Chemistry and physics irritated her, but at the same time, biology brought her pleasure, and chemistry brought her sympathy. In Maite's case, this level represented positive emotions, particularly in chemistry ("tranquility," "satisfaction," and "curiosity") and physics ("curiosity").

Regarding teacher training, both Gina and Maite expressed exclusively negative emotions related to the biology area. Both mentioned feelings of "impotence," with Gina adding "desperation" and "sadness," while Maite noted "concern." Conversely, Celina reported only positive emotions toward learning sciences during her initial teacher training, especially in biology, and described feeling "satisfaction" in physics and chemistry.

In summary, these results account for the diversity of emotions that teachers associate with their learning experiences at different levels and in different areas of knowledge, which also appear to be associated with their enjoyment of learning sciences at each

10.3389/feduc.2024.1472721

formative stage. Additionally, there are some indications that these emotions are in conflict between certain intrinsic interests and curiosity and external factors such as teachers' treatment and class suspensions that generated negative emotions like helplessness and frustration.

3.2 What are the emotions that teachers associate with teaching science?

Secondly, we explored the emotions that teachers associate with teaching science. Specifically, we asked: What emotions do you currently feel, or do you anticipate feeling, if you have to teach content related to biology, physics, and chemistry?

It is noteworthy that, unlike the emotions associated with their training experiences, which revealed a predominance of negative emotions, teachers unanimously associated teaching in all three areas of scientific knowledge areas with a greater proportion of positive emotions, as shown in Table 6 below. The most striking example is Maite, who equally associated physics, chemistry, and biology with emotions such as "tranquility," "liking," "curiosity," and "joy." She also added "happiness" regarding physics and chemistry and "fun" regarding physics and biology. Similarly, Celina pointed out positive emotions such as "curiosity" in all areas and "fun" in physics and biology, adding to the latter other positive emotions like "pleasure," "happiness," "satisfaction," and "joy." Gina also expressed positive emotions regarding teaching physics ("satisfaction"), chemistry ("liking," "fun," "curiosity"), and biology ("pleasure," "liking," "satisfaction," and "joy").

During the interviews, the teachers also expressed a widespread enthusiasm for teaching science. For example, Celina shared her passion by stating, "I love teaching natural sciences topics like animals or the human body," illustrating how the content elicits a favorable emotional response and is consistent with what she pointed out as a student. Similarly, Gina highlighted the topics' ability to captivate students' attention: "I like teaching science because the kids get hooked on the topics," suggesting that the interaction between students and content also significantly influences the teacher's emotional experience. Finally, Maite reflected on her comfort and pleasure in teaching various topics within the subject, emphasizing a shared perception of satisfaction and confidence in her educational practice: "I really like it, I feel comfortable teaching all science topics."

These feelings of security and satisfaction toward science content and teaching correspond to teachers' perceived self-efficacy, that is, how confident they feel about their abilities to carry out a task, achieve a goal, or overcome challenges (Bandura, 1977) in this case, associated with teaching sciences in ECE. It was found that, overall, the self-efficacy level of the participating teachers was high: 4.88/5 for Celina, 4.54/5 for Maite, and the lowest, 4.29/5, for Gina, who has the fewest years of teaching experience (Table 7).

In other words, they generally indicated that they could perform various actions—such as "promoting students' critical thinking, motivating them, establishing routines, encouraging participation, asking questions, and fostering creativity—to 'quite a bit' or 'a great extent'.

This is important, considering that self-efficacy plays a crucial role in teachers effectively achieving what they assess in their motivation, resilience, and innovation (Hussain et al., 2022).

TABLE 6 Survey results on teachers' emotions associated with teaching science in ECE by area of knowledge.

	Gina	Celina	Maite
Emotions associated with teaching Biology	**Satisfaction**	**Fun**	**Tranquility sympathy**
	Tension	**Curiosity**	**Happiness**
	Concern	*Concern*	**Fun**
			Curiosity
			Joy
Emotions associated with teaching Chemistry	**Sympathy**	**Curiosity**	**Tranquility sympathy**
	Fun	*Tension*	**Happiness**
	Curiosity	*Concern*	**Curiosity**
	Tension		**Joy**
	Concern		
Emotions associated with teaching Physics	**Pleasure**	**Pleasure**	**Tranquility sympathy satisfaction**
	Sympathy	**Happiness satisfaction**	**Fun**
	Satisfaction	**Fun**	**Curiosity**
	Joy	**Curiosity**	**Joy**
	Concern	**Joy**	

Positive emotions are indicated in bold and negative emotions are indicated in italics.

Interestingly, in her interview, Maite established a close relationship between emotional valence and preference toward different subject areas associated with her educational trajectory, her confidence in teaching them, and perceived self-efficacy. In particular, she noted that, unlike mathematics, which she does not like to teach and does not feel confident teaching because she always struggled with it during her school years, she enjoys teaching science because she has good memories and feels self-assured addressing it in class. She expressed, "I have to explain things I know, but if it is a subject I do not like [that] I feel insecure teaching them because it is something I struggled with as a student."

In all, despite having had some unfavorable experiences with sciences in their educational trajectories, particularly in teacher training, the participants expressed an overall positive emotional response toward science teaching. However, while biology consistently triggers highly positive emotions in all teachers, it was found that the teaching of physics and chemistry draws a more varied emotional spectrum. These distinctions suggest that particular contents can trigger particular emotional responses. While biology elicits a positive emotional reaction, physics and chemistry can evoke more intricate and, at times, adverse emotional experiences, with a greater presence of negative emotions. Additionally, it is worth noting that concerning educational experiences, biology also stood out as the discipline most vividly remembered and associated with more positive emotions.

Considering these results, a further question arises about how teachers' emotions toward learning and teaching science are associated with their decision-making when planning and implementing science lessons in their ECE classes, as well as identifying other emotional responses that emerge in the planning and teaching processes.

TABLE 7 Findings on the impact of emotions on science teaching among three teachers.

Research question	Findings
What emotions do teachers associate with their previous experiences in learning science?	- Positive emotions (e.g., pleasure, curiosity, fun) were associated with learning biology at the primary and secondary levels. - Negative emotions (e.g., frustration, boredom, irritability) were associated with chemistry and physics, especially at the secondary and teacher training levels. - Factors such as teacher treatment, lack of hands-on activities, and limited exposure to teacher training influenced negative emotions.
What emotions do teachers associate with teaching science?	- Teachers reported mainly positive emotions (e.g., satisfaction, joy, curiosity) when teaching all three science subjects (biology, chemistry, and physics). - Teachers felt confident and enthusiastic about teaching, with high self-efficacy in fostering critical thinking and motivating students. - biology was associated with the most positive emotions among all three teachers.
How do teachers' emotions influence their decisions when planning and implementing science lessons?	- Teachers' emotions shaped content selection, with positive emotions leading to choices that promoted student engagement and curiosity. - During the implementation phase, negative emotions like frustration often arose from student misbehavior or disengagement, which led to adaptations in teaching strategies. - Teachers' emotional responses influenced whether they chose to extend or reduce certain activities.

3.3 What relationships do teachers establish between their emotions and their decisions when planning and implementing science lessons?

Thirdly, as anticipated, we analyzed how teachers associate their emotions with science learning and teaching and their decisions when planning and implementing science lessons in ECE. In general, we found intricate connections between teachers' emotions and pedagogical practices across the different planning and implementation phases. More specifically, teachers' emotions related to their formative trajectories and expectations toward science teaching influence lesson planning, particularly regarding content selection (i.e., which topics they decide to teach and why). In addition, the emotions they experienced as they implemented their science lessons accounted for some of the decisions they took during the interactive phase and how they planned subsequent classes.

During the preactive phase, teachers' emotions shaped their decisions regarding content selection and pedagogical strategies. For instance, Celina's preference for topics like "human body" and "identity" stemmed from her desire to foster students' interest in adaptation and to create a secure classroom environment by encouraging them to talk about themselves and their preferences. In this way, it was found that the decision-making process was driven by personal needs, emotions, and states of mind rather than strict adherence to curriculum guidelines or science didactics. In particular, as she expressed in the interview, Celina planned her lessons considering the emotions of satisfaction and confidence she experienced in prior teaching experiences: "I taught these topics before, and they helped children adapt." However, she also expressed concern by adding, "…but every group is different; it might not work with this group."

Similarly, Gina's planning was driven by the intention to motivate her 4-year-old students. She selected topics fostering their engagement and satisfying her need to see students enthused about learning science, such as "discovering dinosaurs" and "the solar system." Specifically, she named positive emotions such as feeling "pleasure" and "satisfaction" associated with students' engagement with her lessons in prior teaching experiences: "During my teaching practicum, I taught a unit on dinosaurs, and the children got engaged. "Teaching science excites me because kids get involved… I loved seeing them digging for dinosaur bones." As in this example, emotions toward science teaching influenced Gina's instructional strategies, influencing the depth and breadth of content covered.

In the case of Maite, we found that the pursuit of promoting students' interest and motivation, which gives her a greater sense of confidence and satisfaction, also guides her decisions when choosing the content to address in her science classes during the planning phase. Additionally, contrary to the other two cases, she also explained that she considers the recommendations from the literature on science didactics and the curriculum for the area. As a result, we identified that she includes less common content in her planning related to physics, such as "materials," "light and shadows," and "forces." This is interesting because, although the teacher associated certain positive emotions with learning and teaching physics (see Tables 5, 6), it did not stand out, especially at first. However, in the interview, the teacher expressed feeling joy when planning this content because she knows it will spark interest and meaningful learning in her students. She stated, "I want to leave a mark so that the children have good memories of this school stage."

So far, the results indicate that teachers' needs and emotions influence the decision to select certain areas, content, and didactic activities. Teachers' decisions in the planning phase are oriented toward meeting their needs (achieving adaptation, motivation, and controlling discipline). If they believe that their planning will meet these needs, they feel positive emotions, but if they believe they will not be able to meet these needs, they feel negative emotions.

In the interactive implementation phase, these emotional undercurrents continued to shape teachers' classroom practices. Interestingly, at this stage, we identified that teachers referred to negative emotions in a greater proportion, typically elicited by students' misbehavior or lack of engagement with the proposed activities, which made them feel insecure, uncomfortable, or lacking in control.

For example, Celina's need for order and respect influenced her classroom management strategies, eliciting emotions of frustration or satisfaction depending on student behavior and engagement levels. In the class observations, we noticed that Celina continuously called students' attention, asking for silence and reminding them of good behavior rules: "Everyone in their place, no talking, hands under the desk until I say so." In the subsequent interview, she

reflected on this, stating, "I strive to maintain respect in class," and added that she feels frustration and anger when there is disorder and disrespect. On the other hand, we identified that the teacher used different strategies to promote active student participation, such as organizing them into small work groups to carry out experimental activities. When these proposals worked well and generated motivation and curiosity among the children, Celina reported feeling happiness: "Seeing the children's excitement with the experiment filled me with happiness…" However, when students get distracted or do not comply with the rules, the teacher says she again feels anger, frustration, and discomfort: "The lack of attention makes me uncomfortable." In many cases, the teacher changed her didactic strategies, making them more teacher-centered or shortening the time allocated for the activities.

In Gina's case, we observed that, as planned, she began her classes by talking with the students about topics close to them. This action responds to her need to see her students motivated to learn. When watching her class videos during the post-active interview, the teacher expressed feeling pleasure and satisfaction upon identifying that the students were indeed motivated and that their participation in the conversations was high. For example, this was reflected in her statements: "I enjoy teaching science because the children get engaged and participate… It brings me joy to see them." Additionally, she expressed that her goal is to create an environment where students feel safe to express themselves and that she often feels afraid of making interventions that might block students' inspiration, creativity, and thinking: "I just think that maybe my responses could block them… what I do not want is to create that."

On the other hand, similar to Celina, it was observed that Gina had to call out disruptive students on several occasions to maintain classroom order. She noted that this causes her concern and frustration: "Interruptions are daily… it's hard to get the class back on track afterward because the rest get distracted."

Coinciding with her colleagues, Maite also reported feeling positive and negative emotions during the interactive phase of implementing her science classes. As in the other cases, it was found that Maite seeks to stimulate curiosity and active participation among her students, striving to establish and maintain a good classroom climate and healthy relationships. When these goals are achieved, she associates them with feelings of pleasure and satisfaction. However, in the interview, she emphasized that, on many occasions, the students get distracted and are disorderly, which causes her frustration, concern, and anger. For example, she explained: "…There is something I am not doing, and I first get angry with myself… but sometimes it's something that some students always do… most of the classes I feel frustration and concern because I cannot achieve a good environment…." It should be noted that these types of experiences led her to modify the activities she had planned, typically shortening their duration, making room to, for example, review classroom behavior rules, and demotivating her from continuing to conduct science classes that involve active student participation in observing phenomena and handling materials. As such, we found that Maite's efforts to maintain a conducive learning environment were challenged by emotional responses to student behavior, affecting her teaching strategies and content delivery.

Overall, this study highlights the complex interplay between teachers' emotions, their instructional decisions, and classroom dynamics in science education. Positive emotions toward specific disciplines often enhanced enthusiasm and engagement, while negative emotions sometimes resulted in avoidance or adaptation of instructional plans. The imperative to maintain order, foster respect, and motivate students elicited a range of emotional responses that significantly shaped teaching strategies and the overall classroom atmosphere, impacting both lesson planning and implementation of science activities.

The results of this study highlight the complex relationship between the emotions of the three participating teachers and their past experiences, both in learning and teaching science. Through surveys and interviews, a range of emotions were identified that these teachers associate with their previous educational experiences and current classroom practices. These emotions not only shape their perception of scientific subjects but also influence their decisions when planning and implementing lessons. The following table summarizes the key findings regarding the emotions of these three teachers and how these emotions impact their pedagogical practices.

As observed in the table, emotions play a critical role in the pedagogical decisions of the three teachers, both in the planning and implementation of science lessons.

Positive emotions typically reflect teachers' interest and enthusiasm for content, while negative emotions often lead to adjustments in teaching strategies to address specific classroom challenges. This analysis underscores that the emotional experiences of these three teachers, particularly regarding specific scientific subjects, directly influence their students' learning environment and educational experiences. Understanding these emotional dynamics may be essential for further improving their approach to science education.

4 Discussion

In this study, we delved into a relevant yet under-researched topic: ECE teachers' emotions toward science learning and teaching and how they are associated with their science lesson planning and implementation. We conducted a qualitative study based on multiple case studies to identify the emotions that three ECE teachers associate with their educational trajectories, expectations toward teaching science, and the planning and implementation of science classes. This study is carried out in a context where, despite the importance of scientific education from the early years of schooling, there is evidence that learning opportunities in science are scarce at this level and could be further enhanced to foster the development of competencies.

The case study provides crucial insights not only within this specific educational context but also for other regions that face similar socio-historical challenges in ECE. Many regions with similar territorial characteristics also experience limited scientific learning opportunities at this educational stage. Therefore, the results of this study could inform educational strategies and policies in areas with comparable social and territorial constraints, demonstrating the importance of supporting teachers' emotional development in science education from an early age. The emotional experiences of these teachers and their impact on pedagogical decision-making could be especially relevant to other regions facing similar issues.

4.1 Emotions associated with previous experiences in science learning

The results reveal a diverse range of emotions experienced by teachers during their science education, significantly influencing their current perceptions and practices. Positive emotions like pleasure, curiosity, and enjoyment predominate in primary education. Teachers Celina, Gina, and Maite fondly remembered their biology classes, indicating an initial fascination with scientific phenomena. In secondary education, emotions are more varied, with a mix of positive and negative feelings. During teacher training, negative emotional experiences, especially in biology, are predominant.

These findings highlight the enduring influence of emotional experiences on teachers' professional growth and instructional practices.

These findings align with previous research emphasizing the importance of emotions in teaching practice. Studies by Bravo et al. (2019), Bravo Lucas et al. (2022), Brígido et al. (2009), Brígido et al. (2010), and Mellado et al. (2014) highlight that past emotional experiences significantly impact teachers' professional development and their approach to teaching science. Our study's novelty lies in its detailed analysis of how these emotions specifically influence the planning and execution of science lessons in ECE, an underexplored area.

A notable limitation is the small, geographically specific sample, which may not capture the full diversity of ECE teachers' experiences and emotions. Self-assessment of emotions and retrospective reflection may be subject to memory and perception biases. External factors like institutional support and resources may also influence teachers' emotions. However, this exploratory study and its results provide some interesting insights that can inform future research lines and the practice and support of teacher training.

Integrating emotions into PCK offers a holistic view of the educational process, recognizing that teachers are emotional beings whose feelings deeply affect their pedagogical practices (Garritz, 2010; Zembylas, 2007). This study significantly enhances our understanding of how teachers' emotions influence the planning and execution of science lessons in ECE, offering new avenues for professional development that consider teachers' emotional wellbeing, for example, by providing opportunities for teachers to identify and reflect on their emotions as well as strategies and tools to manage them, particularly during the interactive and post-active teaching phases.

Future studies should include a broader, more diverse sample of ECE teachers and explore additional contextual factors influencing teachers' emotions and practices. Developing and implementing emotional intervention programs that promote positive emotions toward teaching science would also be beneficial. These programs could be evaluated through longitudinal studies to determine their long-term impact on teachers' self-efficacy and pedagogical practices.

We hypothesize that interventions to boost teachers' self-efficacy and confidence can improve their emotions toward teaching science. These interventions could include continuous training, emotional support, and innovative pedagogical strategies fostering a positive teaching environment. Future studies could test these theories by implementing and evaluating professional development programs that integrate emotional and pedagogical components.

4.2 Emotions associated with science teaching

The emotions associated with science teaching were predominantly positive. Teachers expressed calmness, enjoyment, curiosity, and joy when teaching biology, physics, and chemistry. This high perceived self-efficacy is crucial for their satisfaction and effectiveness in teaching. For example, Maite associated teaching science with happiness and fun, while Celina and Gina mentioned satisfaction and joy in teaching these subjects. These positive emotions translated into greater engagement and enthusiasm, improving the quality of the learning environment. These results align with studies showing that high self-efficacy and positive emotions toward science teaching lead to more effective and enriching teaching experiences (Bandura, 1977; Dávila et al., 2015).

However, negative emotions, such as anxiety and stress, significantly impact pre-service teachers' confidence, motivation, and teaching strategies, particularly in subjects such as chemistry and physics. Borrachero Cortés et al. (2016, 2017) highlight that these emotions often lead to reliance on traditional methods and resistance to innovative approaches, such as inquiry-based learning. Dávila-Acedo (2017) and Expósito et al. (2023) emphasize that negative emotions hinder self-efficacy, while positive emotions enhance it. Alvarado et al. (2019) note that these emotions can influence the classroom environment and student learning. Nonetheless, Merino et al. (2020) suggest that a positive emotional environment improves attitudes toward teaching science, making it essential to address both cognitive and emotional aspects of teacher training (Merino, 2018).

Our study focuses on how positive emotions influence science teaching in ECE, a less-explored area. One limitation is that negative emotions were not deeply examined, which could provide a fuller picture of teachers' emotional experiences. Additionally, self-reported self-efficacy may introduce biases. Emotionally skilled teachers should regulate their emotions and foster positive learning environments through active methods (Agen and Ezquerra, 2021; Alvarado et al., 2019).

This study sheds light on the role of emotions in science teaching and underscores the need to support teachers' emotional development to enhance education quality. Future research could explore how self-efficacy interventions affect teachers' emotions and practices. Investigating specific emotions and teaching strategies could help create tailored interventions. Professional development programs that combine emotional and pedagogical training may boost self-efficacy and promote positive emotions in teaching science. Future studies could assess these programs across various educational settings.

4.3 Relationships between emotions and decisions in planning and implementing science lessons

Emotions play a crucial role in the planning and implementation of science lessons. Teachers are guided not only by their actual emotions experienced during teaching but also by anticipated emotions or affective forecasting, which refers to their emotional expectations regarding future classroom interactions. For example, Celina selected topics such as "the human body" and "identity" with the expectation that these contents would generate a positive experience for students,

reflecting both her satisfaction and concern for creating a safe environment. Similarly, Gina adjusted her teaching strategies by anticipating how her students might react, demonstrating that positive anticipated emotions foster a more active and dynamic learning environment, while negative anticipated emotions often lead to adjustments or changes in the original plans.

These findings align with previous literature that explores the impact of emotions on pedagogical practice and classroom dynamics (Agen and Ezquerra, 2021; Dávila et al., 2021). The novelty of this study lies in observing how both actual and anticipated emotions influence teachers' decision-making during the planning and implementation of science lessons in ECE.

A limitation of the study is that it did not delve deeply into how specific anticipated emotions affect different aspects of planning and implementation. Additionally, the lack of longitudinal analysis limits the understanding of the long-term impact of these emotions on pedagogical practices.

The results highlight the complex interaction between teachers' emotions, pedagogical decisions, and classroom dynamics. Positive emotions toward specific disciplines increased enthusiasm and participation in the classroom, while negative emotions, both present and anticipated, led to avoiding or modifying initial plans. For instance, anticipating negative emotions such as stress or frustration led some teachers to simplify activities or avoid more complex topics, while positive anticipated emotions motivated the adoption of more interactive approaches. In this way, teachers' positive emotions not only enhance their disposition toward teaching science but also enrich the scientific learning opportunities they offer their students (Ford et al., 2023).

Future research could focus on how different emotional management strategies support teachers in effectively planning and implementing science lessons. It would also be valuable to explore the relationship between teachers' emotional wellbeing and students' academic performance in science.

In conclusion, teachers' emotions toward science, both from their own learning experiences and in their teaching practices, play a crucial role in the quality and effectiveness of early childhood science education. It is essential to continue researching this affective dimension and to develop interventions that strengthen teachers' self-efficacy and positive emotions toward science, as this is key to ensuring high-quality science education from the earliest years of schooling—a pressing challenge.

While we cannot precisely determine how many teachers in Argentina are implementing improvements in early childhood science education, nor how representative the emotional experiences of Celina, Gina, and Maite are, the analysis of these cases opens new opportunities to explore how teachers can gain the confidence and assurance needed to design and implement scientific literacy proposals from early childhood. This type of study raises important questions about how to develop more effective strategies to promote science teaching and shape well-rounded citizens for the 21st century.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

FG: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. MF: Writing – original draft, Writing – review & editing. ML: Conceptualization, Data curation, Formal analysis, Writing – review & editing. EB: Writing – original draft, Writing – review & editing. GA: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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