Journal of Research in Science Teaching

WILEY

JRST

RESEARCH ARTICLE OPEN ACCESS

Emotions Experienced by Preservice Early Childhood Teachers During a Training Program in Inquiry-Based Science Education

María Marta Alarcón-Orozco[1] | Antonio Joaquín Franco-Mariscal[1] | José María Oliva[2] | Ángel Blanco-López[1]

[1]Science Education, Facultad de Ciencias de la Educación, Campus de Teatinos, Universidad de Málaga, Málaga, Spain | [2]Science Education, Facultad de Ciencias de la Educación, Campus Universitario del Río San Pedro, Universidad de Cádiz, Puerto Real, Cádiz, Spain

Correspondence: Antonio Joaquín Franco-Mariscal (antoniojoaquin.franco@uma.es)

Received: 20 November 2023 | **Revised:** 1 February 2025 | **Accepted:** 4 February 2025

Funding: This work was supported by the Spanish Government (Ministerio de Ciencia, Innovación y Universidades/Agencia Estatal de Investigación), MCIN/AEI/10.13039/501100011033. Open access funding provided by Universidad de Málaga / CBUA. [Correction added after first online publication on 26 June 2025. Funding information has been updated.]

Keywords: early childhood education | emotions | inquiry | preservice science teachers

ABSTRACT

The influence of emotions on teaching –learning processes is a topic of increasing interest in science education research. This study explores the emotions experienced by 121 preservice early childhood teachers during a training program in inquiry-based science education. Using a checklist of nine emotions (both positive and negative), participants indicated the emotions they experienced at three stages of the instruction: at the outset, after experiencing an inquiry cycle as science learners, and after designing an inquiry cycle as teacher trainees. Only five of the emotions (interest, concentration, confidence, enjoyment, and insecurity) were reported at all three stages, and closer analysis showed that their prevalence varied depending on the phase of the inquiry cycle and the role that students were in (i.e., science learners or teacher trainees). In both roles, insecurity was generally associated with the initial phases of inquiry (problem formulation, designing experiments, and choosing variables); enjoyment was more prevalent during the phases of realization of the experience in the science learner role and of data analysis in the teacher trainee role; and confidence was particularly associated with the drawing conclusions phase in both roles. These results suggest that in order to understand preservice early childhood teachers' emotions in relation to inquiry-based science education, it is necessary to consider the different phases of inquiry, each of which may generate a different emotional response. When instructing preservice teachers in the use of inquiry tasks, their emotions are also likely to vary depending on whether they are engaging with the approach as science learners or teacher trainees.

1 | Introduction

Inquiry-based science education (IBSE) is now seen as a useful way of promoting scientific literacy and arousing students' interest in science (Worth 2010), and it may be employed with learners of different ages, including in early childhood (McNerney and Hall 2017; Samarapungavan et al. 2008, 2011). Although the importance of IBSE is recognized by researchers, education policymakers, and in curricula, it has yet to be widely implemented as a classroom approach to science education (Cruz-Guzmán and Martínez 2022; Franco-Mariscal 2024; Gerde et al. 2018; Larimore 2020; Magee and Flessner 2012). In the early childhood context, there are several possible reasons for this, one of which is teachers' limited experience of designing and applying inquiry-based learning strategies (Brenneman et al. 2009; Pendergast et al. 2017). Consequently, there is a need to afford teachers opportunities to engage with

IBSE, especially during their initial training (Davidson et al. 2022; Romero-Ariza 2017). This training should address not only the processes of the sciences and science content but also preservice teachers' attitudes toward science (Pendergast et al. 2017; Riegle-Crumb et al. 2015), the emotions they experience in relation to teaching science to early childhood learners (Gerde et al. 2018), and how these emotions may influence the teaching and learning process (Jaber et al. 2022; Marcos-Merino 2019; Pekrun 2005; Schutz and Pekrun 2007; Schutz et al. 2009).

Although there is a considerable body of research on emotions in science education (Mellado et al. 2014; Sinatra et al. 2014), little attention has been paid to the emotions that preservice early childhood teachers (PECTs) may experience when being introduced to the inquiry-based approach (Bellocchi et al. 2014; Smit et al. 2021). In our view, there are two key areas where a more detailed understanding is required: the first concerns the emotions they experience in different phases of the inquiry process (e.g., problem formulation, establishing hypotheses, designing experiments, etc.), insofar as these require distinct types of knowledge and skills; the second involves identifying and differentiating what they feel when adopting different roles during instruction in IBSE, that is, their emotions in the role of science learners versus what they experience as teacher trainees. The present study, therefore, aims to identify the emotions that PECTs experience during a training program in IBSE and to examine whether these emotions change as they progress through the inquiry cycle.

2 | Theoretical and Empirical Underpinnings

2.1 | Inquiry-Based Science Education

Following the publication of the National Science Education Standards in the USA (NRC 1996), and similar reports within the European context, such as *Science education NOW* (European Commission, Directorate-General for Research and Innovation 2007), *Beyond 2000: Science education for the future* (Osborne and Dillon 2008), and *Science education for responsible citizenship* (European Commission, Directorate-General for Research and Innovation 2015), a number of approaches have been proposed with the aim of promoting scientific literacy among citizens and fostering an interest in science among young learners. One such approach is IBSE, the premise of which is that science education should be based on inquiry methods that enable learners to be actively involved in posing questions, designing and performing experiments, and analyzing the results obtained (Sjøberg 2019). Accordingly, IBSE involves formulating and testing hypotheses, solving real-life problems, explaining phenomena through analysis and interpretation of data, and synthesis of ideas (NRC 2000; Pedaste et al. 2015). It also requires the communication of results, giving learners the opportunity to engage in decision-making and to consolidate the skills and knowledge they have acquired. Discussion, communication, and reflection may be considered core elements of the inquiry cycle as they are present throughout.

A key goal and feature of IBSE is therefore that students have the opportunity to act like real scientists, familiarizing them with the scientific inquiry and allowing them to acquire an understanding of its procedures (Lederman et al. 2013; Morales et al. 2022). As Magee and Flessner (2012) put it, IBSE "is grounded in emancipatory and liberating practices where students are encouraged to think for themselves, value personal sense-making and see themselves as profound and critical thinkers" (353).

The Next Generation Science Standards (NGSS Lead States 2013), based on the framework for K–12 science education of the National Research Council (NRC 2012), emphasize engagement in "science and engineering practices" as one of the three key dimensions of the framework, alongside "crosscutting concepts" and "disciplinary core ideas." The NGSS (NGSS Lead States 2013) considers that the eight scientific practices it includes (asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; obtaining, evaluating, and communicating information) provide a more comprehensive understanding of what inquiry in science entails, encompassing a broad range of cognitive, social, and physical practices.

Bevins and Price (2016) propose an innovative model of IBSE that encompasses three dimensions: conceptual, procedural, and personal. The conceptual dimension includes scientific facts and theories that contextualize the phenomenon under study and help formulate scientific questions. The procedural dimension involves the collection and management of data, ensuring that evidence is interpreted and communicated with reference to observed ideas and data. Finally, the personal dimension highlights the importance of intrinsic motivation and autonomy in the learning process. This dimension is essential for fostering active engagement and a positive disposition toward scientific inquiry. Bevins and Price (2016) argue that this model enables future teachers to actively interact with scientific content and processes, preventing inquiry from becoming a series of mechanical steps and instead supporting the meaningful and autonomous construction of learning.

According to these authors, using the three-dimensional inquiry model is an effective way to avoid algorithmic and passive learning. It is essential for classroom science inquiry, as it more accurately reflects authentic science compared to other inquiry models. Moreover, it promotes learner motivation and has the potential to encourage student autonomy, thereby fostering a greater sense of ownership, positive attitudes toward science, and interest in studying science or pursuing science-related careers.

We agree with these authors that the integration of these three dimensions fosters an approach to inquiry that seeks not only content comprehension but also the ability to handle evidence and an intrinsic commitment to learning. All of these aspects are key elements in the training of teachers committed to science education in early childhood.

2.2 | Inquiry-Based Science Education in Early Childhood Education

Various studies have shown that preschoolers who receive systematic science instruction are able to demonstrate "a functional understanding of scientific inquiry processes and of

important life science concepts during their investigations" (Samarapungavan et al. 2008, 868), especially when their learning is guided by an adequately trained adult (Gropen et al. 2017). Similarly, Monteira and Jiménez-Aleixandre (2016) found that early childhood learners are able to engage in scientific practices and enjoy observing, thinking about, and questioning the natural world (Worth 2010), reflecting what is a natural tendency at this age (Eshach and Fried 2005; French 2004; Ramanathan et al. 2022). Research on the development of cognitive flexibility also suggests that children aged 4 years are able to revise their predictions, and ultimately their ideas, if provided with more information (Fischer 2012; Gropen et al. 2011).

Despite the advantages of IBSE in preschool education (Ramanathan et al. 2022), it cannot be considered a widely adopted approach at this educational level. This is largely due to the lack of training and confidence that teachers exhibit toward this approach. As Lee and Shea (2016) point out, preservice teachers will only be able to implement IBSE effectively if they fully understand what inquiry is, are aware of the benefits and challenges it brings, and are given sufficient opportunities to experience it in practice. Research suggests, however, that PECTs lack preparation in designing and implementing science education, leaving them with little confidence in their ability to teach science (Gerde et al. 2018; Pendergast et al. 2017). This self-perception may be due not only to limited training but also to insufficient support resources and opportunities for professional development (Erden and Sönmez 2011; Gerde et al. 2018; Hamlin and Wisneski 2012; Martínez-Chico et al. 2020). Also noteworthy is that levels of scientific training have been found to vary widely among preservice elementary science teachers, some of whom hold erroneous beliefs or ideas about the nature of science and its practice (Lee and Shea 2016; Llewellyn 2001; Magee and Flessner 2012). A related and important factor to consider here is that teachers may have pessimistic feelings or an aversion toward science based on their own experiences of school science, which will then interfere with their ability to teach the subject (Edwards and Loveridge 2011; Gerde et al. 2018; Riegle-Crumb et al. 2015). Overall, the key issue appears to be a lack of confidence among PECTs regarding their knowledge and ability to teach science (Brenneman 2011; Membiela et al. 2022). This lack of confidence is an indicator of the importance of emotions in science education and in teacher training (Bellocchi et al. 2014), particularly for using inquiry-based approaches (David and Bellocchi 2018).

2.3 | Emotions in the Teaching and Learning of Science Education

Emotions are understood as multicomponent changes in an organism's psychophysical system that arise in response to events or situations important to the organism (Scherer and Moors 2019). They encompass a wide range of aspects, including feelings, cognitive evaluations, motivations, motor expressions, and physiological changes. The nature of these responses has been shaped by evolutionary adaptation and sociocultural contexts (Shuman and Scherer 2015). Furthermore, emotions can have significant effects on factors such as students' concentration, engagement, and task performance (Pekrun et al. 2002; Pekrun and Linnenbrink-García 2012).

In the field of neuroscience, Davidson and Begley (2012) demonstrated the mutual interdependence of emotions and cognition in learning, as emotions have a significant impact on reasoning, memory, decision-making, and attitude toward learning. As a result, emotions are considered integral to the learning process, giving rise to a field of educational research focused on social–emotional learning, including the regulation and awareness of emotions, social communication, and collaboration skills (Immordino-Yang et al. 2019). Similarly, Olitsky and Milne (2012) suggest that attitudes and emotions can either facilitate active student learning or hinder their capacity to learn, leading to demotivation and disinterest.

In this regard, Immordino-Yang et al. (2019) state that, particularly in young people, the brain develops in response to opportunities to actively and safely engage in rich and meaningful environments, social relationships, emotions, and socially transmitted ideas and information. Furthermore, research reveals that the brain's malleability and evolutionary plasticity enable us to adapt to environmental demands and learn, largely triggered and organized through socially enabled and emotionally driven cognitive development opportunities. Therefore, high-quality social interaction is both a fundamental opportunity and a responsibility for education.

Pekrun (2014) classifies emotions in the academic context into four groups. The first group consists of *achievement emotions*, which are linked to the possibilities of success or failure in an academic task where individual performance is measured. Within this group, emotions such as enjoyment of learning; hope and pride related to success; and shame related to failure can be found. The second group corresponds to *topic emotions*, which are related to the content presented in lessons and encompass empathy, anxiety, disgust, and enjoyment. The third group comprises *social emotions* related to teachers and peers in the classroom, such as sympathy, love, admiration, compassion, contempt, envy, or anger. The fourth group includes *epistemic emotions* triggered by cognitive problems, such as surprise about a new task; curiosity, confusion, and frustration when facing obstacles; and the pleasure experienced upon problem resolution. Epistemic emotions are particularly important in learning situations involving new and non-routine tasks.

On the other hand, the circumplex model proposed by Feldman-Barrett and Russell (1998) considers that emotions have two fundamental dimensions: valence and activation, in such a way that each emotion can be understood as a combination of these two aspects. Emotions are grouped based on their valence, with positive emotions being pleasant, such as enjoyment, interest, and curiosity, while negative emotions are characterized as unpleasant, including boredom, shame, or insecurity. The other important dimension is activation, which differentiates emotions based on whether they predispose toward or discourage activity, with some being activating, like curiosity, and others being deactivating, such as calmness or confidence (Membiela et al. 2022).

Pekrun and Perry (2014) and Pekrun et al. (2023), within the control-value theory of achievement emotions, propose a three-dimensional taxonomy that classifies these emotions based on their object focus, valence (or pleasantness), and arousal (degree of activation). Regarding object focus,

emotions comprise two different aspects: the type of object and the temporal relation between the person and the object at the time of the emotional experience. In terms of type of object, emotions can be linked to either outcomes or activities. For instance, teachers' pride or satisfaction in achieving their goals is an outcome-related achievement emotion, while boredom during teaching is an activity-related emotion. In terms of temporal relation, any object of emotion can be located in the present, future, or past. As such, it is possible to distinguish between concurrent emotions that occur parallel to an ongoing action or event, prospective (i.e., anticipatory) emotions related to future actions and events, and retrospective emotions related to past actions and events. Valence refers to whether emotions are positive/pleasant or negative/unpleasant, and activation indicates the extent to which an emotion is activating (high arousal) or deactivating (low arousal) (Pekrun and Perry 2014; Pekrun et al. 2023).

Although the theories of Feldman-Barrett and Russell (1998) and Pekrun and Perry (2014) are distinct, they share some similarities and offer valuable theoretical frameworks for understanding how emotions influence human behavior and learning. Both theories highlight the importance of valence and activation of emotions; however, Pekrun and Perry (2014) introduce an additional dimension related to object focus, offering a more comprehensive perspective in the educational context.

For all these reasons, emotions should be regarded as "an integral part of the process of science learning and learning of how to teach science" (Jiménez-Liso et al. 2021, 49). King et al.'s (2015) research on the role of emotions in science education focused on three areas: (a) the emotional climate in the classroom (e.g., Immordino-Yang et al. 2019); (b) students' emotional expressions in science classes (e.g., Linnenbrink and Pintrich 2002); and (c) teachers' emotions during the implementation of inquiry tasks (e.g., Uzuntiryaki-Kondakci et al. 2022).

Uzuntiryaki-Kondakci et al. (2022) indicate that teachers who display positive emotions tend to use student-centered strategies that enhance student motivation and performance, while those who exhibit negative emotions are more likely to employ lecture-centered strategies and struggle to adapt their lesson plans in practice. For students, the findings show that engaging them in science laboratory activities can spark their interest in learning science (Antonio 2018) and foster more creative, flexible, and holistic thinking (Pekrun et al. 2009).

Classroom-based research suggests that positive emotions among learners are associated with engagement in challenging projects and creative problem-solving, while negative emotions have been linked to poor academic performance and school attrition (Bellocchi 2015; Pekrun and Linnenbrink-García 2014). Among teachers, however, Darby (2008) found that negative emotions were also a prerequisite to improvement, insofar as they threatened their view of themselves as professionals and acted as a stimulus to change. Bellocchi (2018) similarly found that when students experienced negative emotions during inquiry tasks, some feelings, such as insecurity (due, for example, to equipment malfunction), would impede their learning, whereas others, such as frustration when an experiment did not work as expected, could promote learning. In light of the above, we share the view of Jiménez-Liso et al. (2021) when they state that emotions are not always positive or negative, but instead should be seen as more complex phenomena that exist along a continuum.

Epistemic and achievement emotions play a particularly significant role in inquiry processes involving executive functions such as planning, decision-making, goal setting, and organization (Palmer 2009). In this context, Jaber et al. (2022) argue that engaging in extended scientific inquiry enables teachers to develop epistemic empathy for their students—by tuning into and appreciating their students' intellectual and emotional experiences in science, which, in turn, supports teachers' responsiveness in the classroom. Furthermore, the development of the inquiry sequence necessitates considering concentration, which refers to the cognitive process of sustaining attention on a task for a specific period, even in the face of frustration and boredom (Parasuraman and Davies 1984). However, concentration can also be seen as an emotional implication in certain contexts (Pekrun et al. 2002) or as an emotional state (Anderson 2005), since intense concentration is often accompanied by a higher emotional involvement and a sense of immersion in the task.

It is vital, therefore, that PECTs are exposed to activities that help them appreciate the advantages of inquiry-based learning and engage emotionally with it (Jiménez-Liso et al. 2021, 2022). Reeve (2013) considers that emotional engagement manifests as enhanced curiosity, which is also reflected in increased interest and enthusiasm and a reduction in anxiety and stress.

2.4 | Emotions and Initial Teacher Training in Inquiry

As already noted, scant attention has been paid to the emotions that PECTs may experience in relation to inquiry-based science tasks (Bellocchi et al. 2014; Jaber et al. 2022; Smit et al. 2021). However, there is research examining the influence of emotions among preservice elementary and secondary science teachers (Davidson et al. 2020; Membiela et al. 2022; Wilder et al. 2019). Interestingly, these studies suggest that the quality of education depends primarily on the ability of teachers to create an emotional climate that favors the teaching-learning process (Frenzel et al. 2018; Schutz et al. 2009). In this regard, Yeigh et al. (2016) argue that in order to fully understand learning, it is necessary to include affective measures that can help to identify the cognitive–emotional aspects of learning that impact interest, persistence in the face of difficulty, and the ability to listen actively to others and to respond to feedback in a critical and constructive manner.

According to Robertson et al. (2015), inquiry-based experiences should be understood as a form of responsive teaching, where teachers attentively engage with their students' thinking and use their interpretations of students' experiences—including their everyday knowledge, questions, and curiosities—to make real-time instructional adjustments and adapt longer-term lesson

plans, while also taking their emotions into account (Jaber et al. 2022). Consequently, it is essential that preservice teachers experience inquiry from this perspective as learners during their training.

Similarly, implementing inquiry-based science activities in the classroom requires the simultaneous application of theoretical knowledge and practical skills, and the cognitive load this entails may lead to feelings of insecurity and stress (Smit et al. 2021). These feelings and how they pertain to doing science should also be a focus of discussion with preservice teachers (Jaber et al. 2022).

Riegle-Crumb et al. (2015) found that exposing preservice elementary teachers to inquiry-based science content courses promoted a positive change in their attitudes toward science, increasing their confidence and enjoyment, and decreasing their anxiety about the subject. This could translate into greater perceived self-efficacy in science instruction in the classroom (Gerde et al. 2018) and, therefore, a stronger emotional engagement (Reeve 2013), making it more likely that preservice teachers will feel capable of implementing inquiry-based science tasks after the transition to professional practice.

This highlights the importance of preservice teachers being able to identify their own emotions, as well as those of their students, so as to use them to drive rather than hinder the achievement of learning goals. While the literature has addressed studies regarding the impact of emotions on students during their engagement in inquiry practices, especially concerning interest (Palmer 2009), it is essential to take into consideration that this kind of activity encompasses a sequence of stages, each involving complex cognitive processes, as mentioned earlier. Therefore, it is relevant to analyze the emotions expressed by PECTs at each stage according to the role played by them in the training program. This objective stands as the main focus of the study.

3 | Research Questions

Research in science education on inquiry-based learning emphasizes its effectiveness in fostering scientific skills and cultivating positive attitudes toward science (Bevins and Price 2016; Pedaste et al. 2015). This study focuses on PECTs and seeks to address a critical research gap in the literature: how PECTs experience and regulate their emotions when engaging with scientific inquiry during their professional training (Davidson et al. 2020; Membiela et al. 2022). While models such as the one proposed by Bevins and Price (2016) integrate conceptual, procedural, and motivational dimensions, their implementation and the resulting impact on PECTs' emotions remain largely unexplored, particularly since much of the existing research focuses on secondary education or in-service teachers. This study aims to bridge these research gaps by examining how a training program in IBSE affects PECTs' emotions and attitudes, as well as how these emotions fluctuate throughout the inquiry process. The ultimate goal is to provide a richer understanding of the specific training needs of early childhood educators.

Based on the assumption that the emotions experienced by PECTs in relation to IBSE may change as they become more familiar with the approach, and also that their emotions may differ depending on whether they are engaging with inquiry in the role of science learners or as teachers trainees, the present study aimed to address the following questions:

Research Question 1 (RQ1). *What emotions do PECTs report in relation to IBSE prior to using this approach?*

Research Question 2 (RQ2). *To what extent do the emotions they experience during the training program in IBSE differ according to the role they are in (i.e., engaging with the inquiry approach as science learners versus as teacher trainees)?*

Research Question 3 (RQ3). *Within each of these two roles (i.e., science learners vs. teacher trainees), to what extent do the emotions they experience vary depending on the phase of inquiry they are engaging in (problem formulation, conducting experiments, etc.)?*

4 | Method

4.1 | Learning Context

4.1.1 | Participants and Formative Environment

The participants in this study were recruited through convenience sampling (Patton 2002). Specifically, there were 121 PECTs who were enrolled in the third year of an early childhood education degree program offered by the University of Málaga (Málaga, Spain). They ranged in age from 20 to 56 (M = 23.0, SD = 5.6), and all but two were women. In terms of their previous education, the large majority (78.5%) had not studied science beyond year 9 (14–15 years). This reflects the limited science background that is generally observed among PECTs, who tend to enter university through a humanities or social sciences pathway and often have an aversion to science, most likely due to negative experiences in school science (Alarcón-Orozco et al. 2021). During the 2018–2019 academic year, the 121 PECTs (distributed across two class groups) received instruction in IBSE as part of the degree course module entitled *Teaching the Natural Sciences*, whose goals include introducing PECTs to the processes of the sciences and encouraging a scientific mindset. In particular, the focus was on understanding scientific methodology and promoting scientific thinking and experimentation; designing instructional proposals that consider the relationships between science, technology, society, and sustainable development; and fostering interest and respect for the natural, social, and cultural environment. The module was developed based on the principle of integrating scientific and pedagogical training, allowing PECTs to use their experiences as science learners to build knowledge and skills for teaching science (Peterson and Treagust 1998). According to this approach, the PECTs first engaged in a complete inquiry process as science learners and then explicitly reflected on their experiences to draw implications for teaching (Jiménez-Liso et al. 2021).

The instruction was implemented in a coordinated fashion by two different course tutors (one for each class group), who had

also been involved in designing its content. Both tutors were also researchers in the field of science education, and they had extensive experience in training early childhood teachers.

4.1.2 | Inquiry-Based Science Education Training Program in the Early Childhood Classroom

Most of the PECTs had not experienced inquiry-based learning during their own schooling, and hence they lacked a platform on which to build the skills to develop. Inquiry is a complex activity that requires the coordination of multiple secondary objectives, and a lack of experience can result in a fragmented understanding of the process (Schauble et al. 1991). According to Immordino-Yang et al. (2019), students should have the opportunity to explore and apply their learning in real-world contexts through projects, internships, and/or presentations, accompanied by constructive feedback that enables them to develop more disciplined thinking and address progressively advanced problems.

Therefore, the PECTs first carried out a complete inquiry cycle on the process of yoghurt production as science learners, following which they could analyze the process and apply what they had learned to design similar activities for use in their respective classrooms. To achieve this aim, we chose, from among the various possible approaches to IBSE in the early childhood classroom (Rönnebeck et al. 2016), the proposal described by Rodríguez-Melero et al. (2021), which comprises the following inquiry phases: formulate problem, design experiments, choose variables, conduct experiments, collect data, analyze data, and draw conclusions.

Figure 1 shows the sequence of activities that formed part of the instruction, highlighting the three stages involved (i.e., prior to experience, experience as science learners, and experience as teacher trainees) and the three points at which the PECTs were asked to reflect on their emotions. The instruction included activities designed to be performed by the whole class, by small groups (4–5 PECTs), and by individual students (indicated by the three different *people icons* in Figure 1), and hence it was conducted within a cooperative learning environment. The sequence of activities was designed to span 1 month, comprising eight class sessions, each lasting 2 h, providing a comprehensive experience throughout the duration of the program. We will now describe in more detail the three stages of instruction, which ended with PECTs being asked to reflect on their emotions (the primary focus of the present study).

4.1.2.1 | Stage 1: Introducing the Inquiry-Based Approach. The tutors began by presenting the course module content, clarifying the expectations for the PECTs and outlining the tasks they needed to complete. As previously noted, the PECTs had no prior experience with the inquiry-based approach to science teaching and learning. Therefore, a detailed presentation was given, describing the different phases of inquiry. This included examples of images illustrating how the inquiry approach is applied in early childhood classrooms, which helped the PECTs recognize and understand the various phases of inquiry depicted in these examples. Additionally, the presentation highlighted how this approach is endorsed in the Spanish curriculum as suitable for early childhood education (Spanish Ministry of Education and Vocational Training 2022). The PECTs were then asked to identify and analyze all references to inquiry in

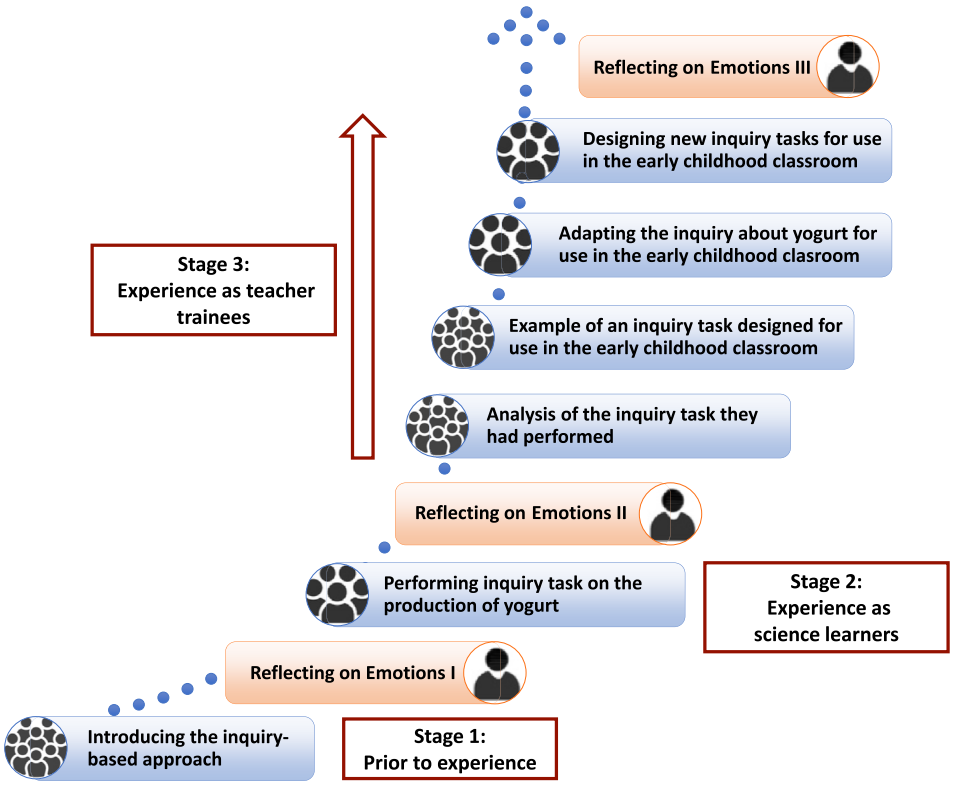

FIGURE 1 | Sequence of activities in the instruction on IBSE.

the curriculum and to discuss their significance collectively. Finally, the PECTs were asked to reflect on their emotions at this stage, that is, prior to actually experiencing the inquiry approach as either science learners or teacher trainees (in Figure 1: Stage 1—Reflecting on Emotions I).

4.1.2.2 | Stage 2: Experience as Science Learners. In the next stage of instruction, the PECTs were given the opportunity to experience a complete inquiry cycle as science learners, in this case using a previously described inquiry task related to the production of yoghurt (Muñoz-Campos et al. 2020). This inquiry is based on a relevant context of daily life, which facilitates learning transfer (Gilbert et al. 2011). Specifically, it focuses on health and diet (OECD 2016) and a particular situation, namely, yoghurt production. Yoghurt is widely consumed by preschoolers (Parra 2012), which may help to pique PECTs' interest and involve them in understanding how it is prepared and the chemical and biological processes associated with it.

This task was performed with the PECTs working in small groups in the role of science learners. Upon completing the task, PECTs were once again asked to reflect individually on the emotions they had experienced while working their way through the different phases of the inquiry cycle (in Figure 1: Stage 2—Reflecting on Emotions II).

4.1.2.3 | Stage 3: Experience as Teacher Trainees. The whole class group was then asked to reflect on and analyze the inquiry task they had just performed in small groups, but this time from the perspective of teachers (i.e., they now assumed the teacher trainee role). They were also introduced to and required to discuss (again as a class group) a different inquiry-based task on the properties of water (color, taste, smell, etc.) that had been designed for use with children aged 3 years (De la Calle 2005). They then returned to their small groups with the task of adapting the inquiry task about yoghurt production for use in the classroom with children aged 3–6 years. Continuing in the teaching role and still in their small groups, PECTs were then asked to design new inquiry tasks that would be suitable for use in the early childhood classroom, basing their proposals on the approach they had experienced during the instruction. The topics addressed by their proposals included how bodies float, soap production, and soil erosion, among others. Finally, the PECTs were again asked to reflect on their emotions, having now completed all three stages of the instruction on IBSE (in Figure 1: Stage 3—Reflecting on Emotions III).

Table 1 describes the training program, indicating the relationship between its training stages, their timing, and the activities carried out by the PECTs.

4.2 | Data Collection Instrument

The emotions experienced by the PECTs were recorded using a self-report checklist previously employed by Martínez-Chico et al. (2020) in inquiry sequences for populations with characteristics similar to those in this study (Jiménez-Liso et al. 2021, 2022). The checklist displays a total of nine emotions (*interest*, *concentration*, *confidence*, *enjoyment*, *insecurity*, *dissatisfaction*, *boredom*, *rejection*, and *shame*), and respondents simply have to indicate whether or not (yes/no) they experienced the emotion and to provide a justification for the cause that evoked it. Both positive and negative emotions are listed so as to avoid biasing responses toward a particular type of experience. Moreover, the instrument's format and length enable the PECTs to meet the requirements presented within, specifically to recall and specify the emotions experienced at each phase of the inquiry (Annex SI).

The instrument included certain emotions considered by Scherer et al. (2013) and Pekrun (2014), as well as some implications (Parasuraman and Davies 1984), or emotional states (Anderson 2005). According to Pekrun and Perry (2014) and Pekrun et al. (2023), the emotions included in the checklist can be classified as shown in Table 2, which also outlines their role in the context of inquiry.

In the present study, the checklist was used as follows: in Stage 1 (Reflecting on Emotions I in Figure 1) the PECTs were simply asked to indicate what they felt about the inquiry-based approach overall, following the tutor's description of it. In the subsequent two stages (i.e., following experience as science learners and as teacher trainees; Reflecting on Emotions II and III in Figure 1) they were asked to indicate the emotions they had experienced in each of the seven inquiry phases (i.e., formulate problem, design experiments, choose variables, conduct experiments, collect data, analyze data, and draw conclusions). In all three administrations of the checklist, they could endorse as many emotions as they experienced in each case. For each emotion endorsed, they were also asked to elaborate on what they felt by adding a brief comment in the corresponding box alongside each emotion in the checklist. Instruments of this kind have been shown to be valid ways of measuring emotions in education (Bellocchi 2015; Marcos-Merino 2019; Mauss and Robinson 2009).

During the presentation of the training program, the meaning of emotions, which they had already received training on during their degree, was discussed. Additionally, the instrument was reviewed with them to address any potential doubts they might have about it. The completion of the checklist at all three stages of the program was a mandatory activity. PECTs responded to the checklist using pseudonyms to encourage an open expression of emotions.

4.3 | Data Analysis

The data were analyzed using a combination of quantitative and qualitative methods, carried out through three distinct but complementary phases. On the one hand, the descriptive analysis of frequency data yields exhaustive information about the emotions experienced by the PECTs during instruction on IBSE. On the other hand, the correspondence analysis provides a more robust account of the data, insofar as it integrates information from different variables, thereby helping to counteract possible interference due to statistical errors in the data. Finally, the qualitative analysis provides information about minority emotions. Thus, although we believe that the three analytic

TABLE 1 | Training program. Relationship between training stages, activities, and timing.

Stage	Training		Activities	Time
Prior to experience	Presentation of the training program on IBSE and initial data collection for PECTs.	1. Presentation of the training program on IBSE.	Presentation of the training program on IBSE.	2 h
		2. PECTs' first individual reflection on learning and emotions regarding the phases of scientific inquiry.	Completion of a self-report checklist about emotions during the inquiry process (Martínez-Chico et al. 2020).	
Experience as science learners	Implementation of scientific inquiry and construction of knowledge from the context.	3. PECTs are encouraged to carry out a complete cycle of inquiry. For this purpose, an inquiry proposal on yoghurt making (Muñoz-Campos et al. 2020) was chosen due to its ease of implementation and appropriateness for early childhood education settings.	PECTs must design an experiment to prepare yoghurt in class. To that end, they must establish the variables involved (independent and controlled) and design various experiments that can be carried out based on them.	2 h
			PECTs must decide which properties (dependent variables) can be used to assess the quality of the obtained yoghurt. Subsequently, they must design procedures to evaluate these properties and conduct an internet search to explore various scales (color, taste, etc.).	
			PECTs prepare three yoghurts in the laboratory using their designs and a yoghurt maker. After mixing the components, PECTs measure the properties to be evaluated for both the initial mixture and a commercial yoghurt used as a control product.	
			The following day, once the products had been obtained, these properties were measured again. Based on the properties of the commercial yoghurt, the initial mixture, and the final product, PECTs were required to explain the changes, similarities, and differences observed. They also had to determine whether the final product met the criteria for being classified as yoghurt, analyze whether these outcomes were consistent across all three samples, and identify the necessary conditions to obtain yoghurt.	2 h
		4. PECTs' second individual reflection on learning and emotions regarding the phases of scientific inquiry.	Completion of a self-report checklist about emotions during the inquiry process (Martínez-Chico et al. 2020).	

(Continues)

TABLE 1 | (Continued)

Stage		Training	Activities	Time
Experience as teacher trainees	Didactic analysis.	5. PECTs, acting as teacher trainees, must identify the objectives and content within the activities carried out, as well as their contribution to understanding the problem and fostering inquiry development.	PECTs are asked to identify the types of learning they have acquired, specifying knowledge, skills, and attitudes.	2 h
		6. PECTs analyze an inquiry activity conducted with early childhood children, using a template as a guide. In this case, a project about water developed with 3-year-old children was used (De la Calle 2005).	In small groups, the PECTs conduct an analysis of the various experiences included in the project about water to identify the elements of inquiry present. During the discussion, the PECTs are informed that despite the different contexts and topics (yoghurt and water), the elements of inquiry are present in both proposals.	
	Didactic transposition.	7. A scheme is provided to PECTs for designing inquiry activities adapted to early childhood education.	PECTs, working in small groups, must adapt the yoghurt inquiry for early childhood children using the provided scheme.	2 h
		8. Designing inquiry projects for early childhood education.	Each group designs an inquiry project for the early childhood education stage, contextualized within a different everyday life problem.	2 h
		9. Implementation of designed inquiry projects.	PECTs display the inquiry projects in the format of a science fair, allowing attendees the opportunity to interact with them.	2 h
		10. Science fair report.	PECTs assess the projects presented at the science fair, considering the appropriateness of the inquiry for the early childhood education stage and its feasibility. They also offer improvement suggestions for the designs.	2 h
		11. PECTs' third individual reflection on learning and emotions regarding the phases of scientific inquiry.	Completion of a self-report checklist about emotions during the inquiry process (Martínez-Chico et al. 2020).	

TABLE 2 | Classification of the emotions included in the checklist used in the research according to Pekrun and Perry (2014) and Pekrun et al. (2023).

Emotion	Object focus	Valence	Arousal	In the context of inquiry…
Interest	Activity—concurrent	Positive	Activating	Promotes curiosity and the desire to explore and learn more about the investigated phenomenon. It activates the urge to solve the problem as quickly as possible.
Concentration	Activity – concurrent	Positive	Activating	Helps PECTs stay focused on specific inquiry tasks, such as collecting and analyzing data, or making decisions.
Confidence	Outcome—prospective	Positive	Activating	Reinforces the self-perception of PECTs, motivating them to face challenges. It activates participation and the expression of their personal ideas.
Enjoyment	Activity—concurrent	Positive	Activating	Creates a positive environment that promotes continued engagement with inquiry and reduces stress. It activates the recognition that something new has been learned.
Insecurity	Outcome—prospective	Negative	Activating	This may arise from the uncertainty of the research question, data collection, data analysis, and so forth. It activates the search for solutions and fosters learning.
Dissatisfaction	Outcome—retrospective	Negative	Activating	Emerges when the inquiry results do not match expectations. It activates a critical review of hypotheses and procedures.
Rejection	Outcome—retrospective	Negative	Activating	Appears when perceiving that an idea or method is invalid. It may activate a rethinking and the search for alternatives, but it also carries the risk of demotivation.
Boredom	Activity—concurrent	Negative	Deactivating	Indicates a lack of interest or challenge, which may lead to disengagement from the inquiry unless a new motivation is introduced. It deactivates the search for explanations.
Shame	Outcome—retrospective	Negative	Activating	Arises after perceived errors or failures that prevent answering the research question. It may activate self-criticism and improvement, but it also carries the risk of demotivation.

procedures complement one another, the conclusions derived from the correspondence analysis may be more reliable and transferable.

The data analysis was conducted as follows:

a. *Descriptive Analysis*

The responses given by PECTs in each administration of the checklist were tabulated as either 0 (emotion not endorsed) or 1 (emotion endorsed), thus yielding a matrix of quantitative data. Their written justifications for the emotions endorsed enabled us to attribute meaning to their experiences in each case (Dorio et al. 2004).

A descriptive analysis of the frequency of emotions experienced, measured in terms of the percentage of PECTs who endorsed each emotion at each stage of the instruction (i.e., prior to experience, followed by experience as science learners and as teacher trainees) was conducted. For the latter two stages (science learner role and teacher trainee role) the analysis of results considered both the inquiry cycle as a whole and each of its seven phases.

Building on this, a comparative analysis of the frequency of emotions experienced in relation to each phase of the inquiry cycle in each of the two roles (science learner and teacher trainee) was conducted. The different emotions may be considered independent variables as each PECT may endorse as many emotions as were experienced in relation to each phase; for instance, the fact that a PECT endorses the emotion *interest* does not prevent her from also selecting other emotions on the checklist, such as *enjoyment*. For this analysis, we did not consider emotions that were endorsed by fewer than 10% of the PECTs, which was the case for *dissatisfaction*, *boredom*, *rejection*, and *shame*. Consequently, the analysis is focused on the emotions *interest*, *concentration*, *confidence*, *enjoyment*, and *insecurity*.

b. *Correspondence Analysis*

Analysis of chi-square contingency tables and simple correspondence analysis to study the relationship between the emotions

experienced and the different phases of the inquiry cycle (see Figure 4). The purpose of this analysis is to study the association between the categories of two non-metric variables, visualizing it in the form of a perceptual map (Greenacre 2017). To this end, and for the data gathered in the science learner role and teacher trainee role stages of the instruction, we created two-way contingency tables in which the rows corresponded to the different inquiry phases and the columns to the emotions experienced. Given that each PECT could select more than one emotion for each inquiry phase at each stage of the instruction, the categorized data refer not to the number of PECTs but to the number of times a given emotion is endorsed. These tables, therefore, constitute similarity matrices between emotions and inquiry phases. Because the matrices comprise information obtained from the same subjects across different phases of the instruction, they have to be interpreted as stacked tables, which can then be analyzed as in a regular correspondence analysis, provided that caution is exercised when interpreting the results; that is to say, they refer only to the pairwise association between inquiry phases and emotions, not to the relationship between phases (Greenacre 2017). Correspondence analysis is depicted using a dimensional representation, where the proximity between emotions and inquiry phases serves as a measure of their degree of association.

Cohen's w (Cohen 1988) was used to measure the effect size of the chi-square test using the equation $w = \sqrt{\chi^2/[n \times (k-1)]}$, where χ^2 is the value of the chi-square statistic, n is the total number of observations, and k is the number of categories of the variable with the fewest categories. As for the value of 'w' calculated in absolute terms: 0.1 is considered a small effect, 0.3 a medium effect, and 0.5 a large effect (Cohen 1992).

c. *Qualitative Analysis*

A qualitative analysis to explore how the emotions found in lower percentages (*dissatisfaction*, *boredom*, *rejection*, and *shame*) manifest in different phases of the inquiry, as well as in Stages 2 and 3, aims to conduct a more detailed study of the emotions expressed by all PECTs. Additionally, the justifications provided by the PECTs were examined using an inductive categorization process (Charmaz 2006), resulting in a series of emerging categories. This approach allowed for the characterization of the majority of justifications for minority emotions. This process was carried out collaboratively by the two teachers (the first two authors) involved in the implementation. Subsequently, any discrepancies were resolved by consensus during a research team meeting (Hill et al. 2005).

5 | Results

We will now present the results according to the three research questions.

5.1 | RQ1. What Emotions Do PECTs Report in Relation to IBSE Prior to Using This Approach?

Figure 2 shows the percentage endorsements for each of the nine emotions at Stage 1 of the instruction. Note that the sum of percentages is greater than 100 because individual PECTs could select more than one emotion in the checklist. The mean number of emotions endorsed per PECT was 1.42. The

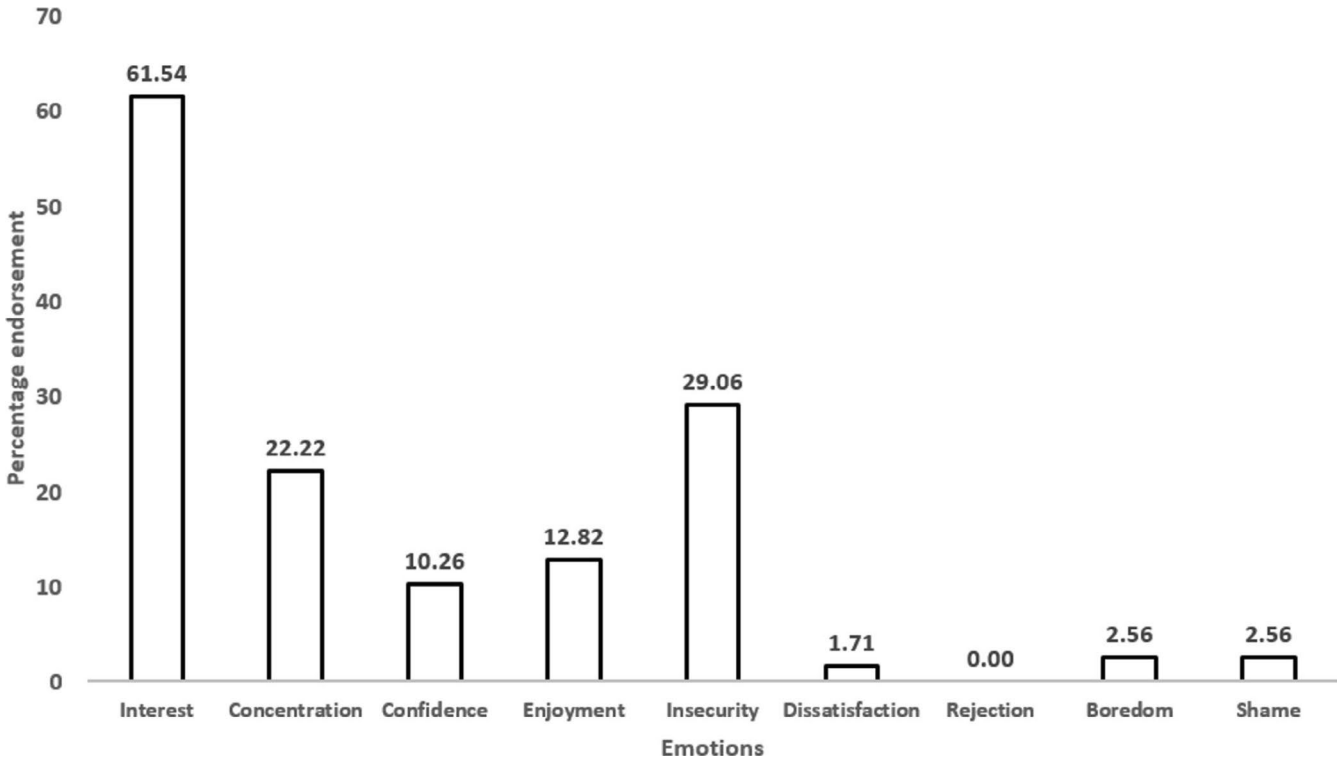

FIGURE 2 | Percentage of PECTs ($n = 117$) who endorsed each emotion prior to the experience of IBSE (Stage 1). Note: In order to express as a percentage the proportion of PECTs who endorsed each emotion in the initial evaluation (Stage 1 in Figure 1), we divided the total number of endorsements for a given emotion by the number of PECTs, and multiplied the result by 100.

majority of the 117 participants, 68.4% (80 PECTs), identified only one emotion, while 27 PECTs (23.1%) reported two emotions, 8 PECTs (6.8%) identified three, and only a small number selected four (1 PECT, 0.9%) or five emotions (1 PECT, 0.9%). Notably, no participant selected more than five emotions.

It can be seen in Figure 2 that *interest*, *insecurity, and concentration*, in this order, were the emotions most commonly endorsed by PECTs at this initial stage. Conversely, none of the PECTs reported feeling the emotion of *rejection*, and only a very small number (2 or 3 PECTs) endorsed *boredom*, *shame*, or *dissatisfaction*. Table 3 shows some quotes from the PECTs to justify the emotions felt.

Among the reasons provided by the PECTs who selected *interest* were a desire to learn and curiosity, whereas *insecurity* was linked to encountering inquiry as a new methodology. Alongside the results for *interest*, those for *concentration* also suggest that the PECTs generally felt positive about the proposed instruction at this initial stage.

Boredom, mentioned on three occasions, was justified by a lack of interest. In all three cases where *shame* was reported, it was accompanied by *interest*, and in two instances, it coexisted with *insecurity*. The justifications provided by the PECTs were more closely related to the latter. Lastly, *dissatisfaction* arose due to the lack of clarity on how to address the topic.

5.2 | RQ2. To What Extent Do the Emotions They Experience During the Training Program in IBSE Differ According to the Role They Are in (i.e., Engaging With the Inquiry Approach as Science Learners vs. as Teacher Trainees)?

Table 4 shows the relative frequency (expressed as a percentage) with which each of the nine emotions was expressed in the roles of science learner and teacher trainee (values are the average across all seven inquiry phases). These percentages allow us to compare the frequency with which different emotions are endorsed, and hence we will refer hereinafter to the prevalence of emotions.

It can be seen in Table 4 that the results show a similar pattern across the two stages of instruction (science learner and teacher trainee roles), as in both cases the most frequently endorsed emotions were *interest*, *enjoyment*, *concentration*, *confidence*, and *insecurity*. Consistent with the results obtained in Stage 1 (prior to experience of inquiry tasks), the other four emotions had a very low prevalence. In order to compare these data with those obtained in Stage 1 (see Figure 2), Table 5 shows the five emotions with a prevalence above 10% in all three stages of the instruction, indicating their sequential order for each stage.

It can be seen in Table 5 that a change in the sequential order of these five emotions only occurs between Stages 1 and 2. The most noticeable changes concern *enjoyment*, which goes from being the fourth to the second most frequently endorsed emotion by the end of Stage 2 of the instruction, and *insecurity*, which drops from second to fifth place in terms of frequency.

TABLE 3 | Justifications provided by the PECTs for different emotions at various stages.

Emotion	PECT's justification
Stage 1	
Interest	"I like to discover and learn new things, and especially to explore those things I don't understand, so I'm interested in finding out more about all this." (PECT089). "Exploring aspects of science in everyday life and sharing this with other students seems really interesting to me." (PECT118).
Insecurity	"I've never done an activity like this and it makes me feel insecure." (PECT051). "I'm very insecure and research is not something I feel at home with." (PECT094).
Concentration	"I was concentrating because it seems really interesting and something that I can put into practice after qualifying as a teacher." (PECT064). "I didn't get distracted during the explanation because it seems interesting" (PECT099).
Dissatisfaction	"I'm not clear on how to address this topic." (PECT096).
Boredom	"I do it because it's mandatory." (PECT023). "It's a topic that doesn't really interest me." (PECT083). "To be honest, I'm not sure what it's specifically about." (PECT103).
Shame	"I don't know how it will turn out, but I'm interested in the activity." (PECT008). "I feel insecure because I'm uncertain if I'll live up to expectations." (PECT01). "I have an interest in learning about different topics that are important and can be applied in early childhood education." (PECT040).
Stage 2	
Dissatisfaction	"I experienced dissatisfaction because not all of our yoghurts yielded good results, and not all of them tasted good." (PECT103, choose variables phase). "A sense of dissatisfaction arose due to the unexpected outcomes." (PECT099, conduct experiments phase).
Stage 3	
Dissatisfaction	"Dissatisfaction because we had to reframe the problem again." (PECT096, formulate problem phase). "During the experiment, I felt somewhat dissatisfied as both my partner and I couldn't find the right ingredient to make the yoghurt turn out well." (PECT026, conduct experiments phase). "While conducting various experiments, I experienced a mix of feelings, from frustration when several experiments didn't yield conclusions that addressed the initial question, to joy when some of them allowed me to verify the initial hypothesis." (PECT045, conduct experiments phase).
Rejection	"Rejection because, at first, I didn't know how to conduct the data analysis properly." (PECT010, analyze data phase).

TABLE 4 | Mean relative frequency (expressed as a percentage) with which each emotion was endorsed in the role of science learners and teacher trainees (Stages 2 and 3 of the instruction; $n = 121$).

Emotion	Stage 2: Science learner role	Stage 3: Teacher trainee role
Interest	51.0	36.7
Concentration	27.5	25.0
Confidence	17.4	22.3
Enjoyment	30.0	35.3
Insecurity	16.9	16.5
Dissatisfaction	1.9	2.4
Rejection	3.4	1.3
Boredom	1.1	1.1
Shame	0.7	0.0

A smaller shift is observed for *confidence*, which moves from fifth to fourth by the end of Stage 2. The sequential order of the five emotions does not change between Stages 2 and 3 of the instruction, suggesting a similar profile of emotional experience when the PECTs engage with inquiry as science learners and as teacher trainees.

The emotions *dissatisfaction*, *rejection*, *boredom*, and *shame*, which were observed in less than 10% of the PECTs, were indicated by the PECTs 56 times in Stage 2, in contrast to 38 times in Stage 3, implying that the advancement of the training program led to a reduced frequency of these emotions being evoked by the PECTs. *Dissatisfaction* and *rejection* stood out as the most significant emotions in both stages. A significant portion of the negative emotions in Stage 2 appeared as *dissatisfaction* during the collect data phase.

In order to elucidate the underlying reasons behind these negative emotions, we conducted an analysis of the justifications expressed by the PECTs when marking each emotion. This analysis led to the identification of seven categories (Table 6).

Some justifications provided by the PECTs for the emotion of *dissatisfaction* in Stage 2 (Table 3) suggest that these emotions cannot be attributed solely to a specific phase, but rather to the overall inquiry process. It appears that some PECTs had not fully comprehended the nature of the inquiry. Therefore, the fact that they did not achieve a product (yoghurt) with the desired characteristics does not necessarily imply a flaw in the inquiry process, as the main goal of the activity is to comprehend this process. Analyzing the obtained product, with its specific characteristics, should encourage them to critically evaluate the procedure and suggest potential improvements if needed.

Upon examining the justifications in Stage 3, a clear correlation emerges between the reasons provided for expressing a specific emotion and the phase of the inquiry cycle to which they are assigned. This underscores a more discerning perspective of each inquiry phase and a heightened comprehension of the overall inquiry process. Some examples of this type of justification are shown in Table 3 for *dissatisfaction* and *rejection*.

5.3 | RQ3. Within Each of These Two Roles (i.e., Science Learners vs. Teacher Trainees), to What Extent Do the Emotions They Experience Vary Depending on the Phase of Inquiry They Are Engaging in (Problem Formulation, Conducting Experiments, etc.)?

The fact that no overall differences are observed between Stages 2 and 3 does not necessarily mean there are no differences in the profile of emotions experienced during these two stages, insofar as differences may be present in relation to particular phases of the inquiry cycle. This is why it is also important to examine whether the emotions endorsed by PECTs within the science learner and teacher trainee roles (Stages 2 and 3, respectively) vary depending on the phase of inquiry with which they are engaging.

Figure 3 plots the frequency with which the five most common emotions (see Table 5) were endorsed in relation to each of the seven phases of the inquiry cycle. The graph on the left corresponds to Stage 2 of the instruction (science learner role), while that on the right corresponds to Stage 3 (teacher trainee role), thus enabling the comparison of the two.

It can be seen in Figure 3 that the frequency with which different emotions were endorsed varies depending on the phase of the inquiry cycle that the PECTs were engaging with. Furthermore, the pattern in the prevalence of the five emotions across the seven phases of the inquiry cycle differs between the two stages of instruction (science learner and teacher trainee role). When the PECTs engaged with the inquiry process as science learners (Stage 2 of instruction), *interest* was a notably more common emotion than *enjoyment*, whereas the difference in prevalence of these two emotions was less marked when they assumed the role of teacher trainee (Stage 3). This same pattern is observable to a lesser extent when comparing the prevalence of *concentration* and *confidence*. Although these differences did not reach the threshold for statistical significance (chi-square test), it may be worth exploring them further in future studies.

Table 7 displays the emotions of *dissatisfaction*, *rejection*, *boredom*, and *shame*, indicating the stages and phases of the inquiry cycle where they appear.

In order to explore more closely how the emotions experienced may be influenced by the phase of the inquiry cycle, we conducted simple correspondence analyses of the results obtained in Stages 2 and 3 (science learner and teacher trainee role). Both these analyses revealed a significant interaction effect between emotions and inquiry phases ($\chi^2 = 79.632$; df = 24, $p = 0.000$, for Stage 2, science learner role; $\chi^2 = 204.599$; df = 24, $p = 0.000$, for Stage 3, teacher trainee role). This indicates that in both Stages 2 and 3 of the instruction, certain emotions were more closely linked to some phases of inquiry than to others. Cohen's w (Cohen 1988) was used to measure the effect size, yielding values of 0.80 and 1.30, which are considerably larger than the 0.5 threshold, beyond which an effect size is considered large (Cohen 1992).

TABLE 5 | The five most frequently endorsed emotions, showing their sequential order for each stage of the instruction.

Emotion	Stage 1: Prior to experience	Stage 2: Science learner role	Stage 3: Teacher trainee role
Interest	First	First	First
Insecurity	Second	Fifth	Fifth
Concentration	Third	Third	Third
Enjoyment	Fourth	Second	Second
Confidence	Fifth	Fourth	Fourth

TABLE 6 | Categories of justifications associated with less-frequent emotions.

		Dissatisfaction		Shame		Boredom		Rejection	
Categories		Stage 2	Stage 3	Stage 2	Stage 3	Stage 2	Stage 3	Stage 2	Stage 3
1.	Knowledge deficiency.	1	3			3	1	2	4
2.	The expected results are not achieved.	12	13				4	2	3
3.	S/he doesn't want to taste the yoghurt.			1				24	
4.	Group organization.		1					1	1
5.	Difficulty for concentration and argumentation.	1		1		3			
6.	Uncertainty about possible outcomes.			3					2
7.	Others.		2	1		1	4		

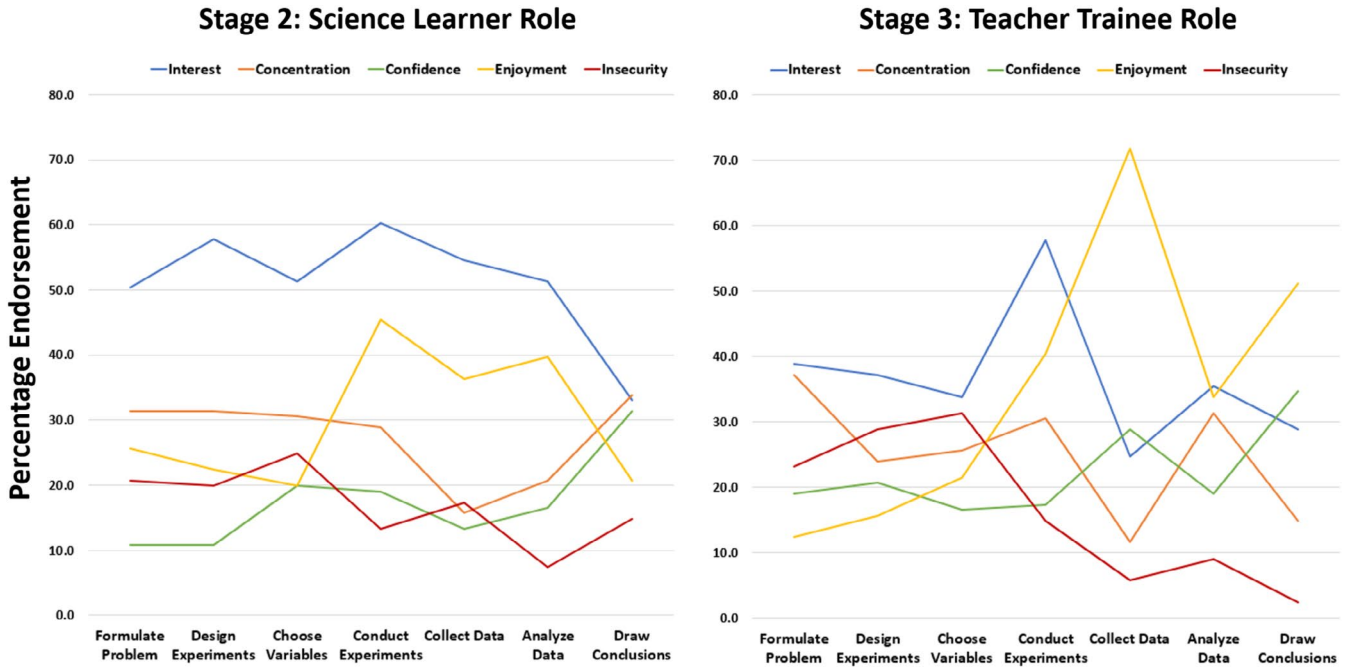

FIGURE 3 | Comparative analysis of the emotions endorsed by PECTs in relation to each of the seven phases of the inquiry cycle for Stages 2 and 3 of the instruction (science learner role and teacher trainee role, respectively).

Figure 4 shows scatterplots resulting from the two correspondence analyses. These plots are two-dimensional perceptual maps that display the position of the different emotions (black circles) and the different phases of the inquiry cycle (grey circles) relative to one another. Correspondence analysis enables the graphical representation of each category of the two variables (inquiry phases and emotions) on the same perceptual map. The coordinates of each point are arranged in such a

TABLE 7 | Frequencies of the emotions dissatisfaction, shame, boredom, and rejection in each inquiry phase, in Stages 2 and 3.

	Dissatisfaction		Shame		Boredom		Rejection		Total	
Inquiry phase	**Stage 2**	**Stage 3**	**Stage 2**	**Stage 3**	**Stage 2**	**Stage 3**	**Stage 2**	**Stage 3**	**Stage 2**	**Stage 3**
Formulate problem	2	2	0	0	3	0	2	1	7	3
Design experiments	0	1	0	0	0	0	1	4	1	5
Choose variables	1	1	0	0	0	1	2	0	3	2
Conduct experiments	2	4	1	0	1	3	0	1	4	8
Collect data	3	6	4	0	0	2	24	2	31	10
Analyze data	5	3	0	0	2	3	0	2	7	8
Draw conclusions	1	2	1	0	1	0	0	0	3	2
Total	14	19	6	0	7	9	29	10	56	38

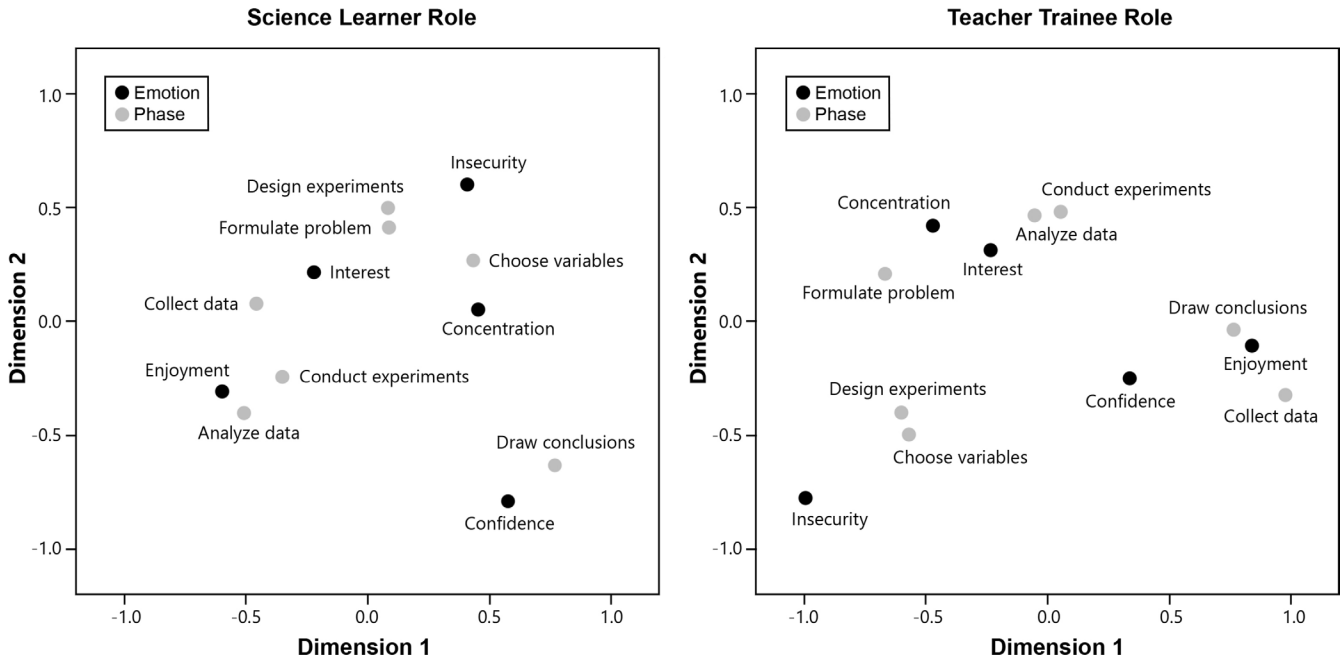

FIGURE 4 | Simple correspondence analysis for the emotions experienced in Stage 2 (science learner role; left) and Stage 3 (teacher trainee role; right) of the instruction.

way that, when plotted on a two-dimensional graph, the proximity between points represents the level of association between the corresponding categories. Because these maps are derived from the analysis of stacked tables (Greenacre 2017), it is important to remember that they only show the association between inquiry phases and emotions, not the relationship between phases.

In the scatterplot for the science learner role (Stage 2: Figure 4, left) some emotions appear to be related to several inquiry phases, while others are associated with just one. Thus, the emotion that was most frequently endorsed by the PECTs throughout the instruction, namely *interest*, appears to be particularly associated with the inquiry phases corresponding to problem formulation, the design of experiments, and data analysis. *Insecurity* seems to be related to problem formulation, the design of experiments, and the choice of variables, while *enjoyment* is linked to conducting experiments and analyzing data. By contrast, *concentration* and *confidence* appear to be associated with just one inquiry phase, namely choosing variables and drawing conclusions, respectively.

It can be seen in the scatterplot for the teacher trainee role (Stage 3: Figure 4, right) that all five emotions appear to be related to more than one phase of inquiry. Thus, both *interest* and *concentration* are associated with problem formulation, conducting experiments, and analyzing data, while *confidence* and *enjoyment* are linked to data collection and drawing conclusions. Finally, *insecurity* is related to designing experiments and choosing variables.

If we compare the maps for the two stages of instruction, it can be seen that the PECTs experience *interest* and *concentration* during the initial phases of the inquiry cycle (i.e., problem formulation, designing experiments, and choosing variables), regardless of whether they are in the role of science learners or teacher trainees.

Also in the science learner role, *enjoyment* appears to be particularly associated with conducting experiments and analyzing data. Finally, the scatterplot for the science learner role also suggests that the PECTs gained *confidence* by the end of this stage of the instruction, insofar as this emotion was associated with the final phase of the inquiry cycle, drawing conclusions. In the teacher trainee role (Stage 3 of instruction), this final phase appears to have generated both *confidence* and *enjoyment*.

6 | Discussion

6.1 | Emotional Landscape in Stage 1

The emotion most commonly experienced by our PECTs across all three stages of the instruction was *interest*, a concurrent activity and a positive activating emotion (Pekrun and Perry 2014; Pekrun et al. 2023) that drives the desire to solve the problem as quickly as possible. This result is consistent with the findings of Antonio (2018) and Palmer (2009) regarding the impact of emotions on students during their engagement in inquiry practices, especially concerning interest.

At the start of the instructional module, prior to the experience of the inquiry-based approach (Stage 1), *interest* was accompanied by *concentration*, another concurrent activity, and a positive activating emotion (Pekrun et al. 2023), although some of the PECTs also experienced *insecurity* (an outcome prospective and a negative activating emotion) (Pekrun et al. 2023). The presence of this latter emotion is in line with previous research showing that PECTs often lack confidence in their ability to teach science (Gerde et al. 2018) and find learning the practical skills required to be particularly demanding (Smit et al. 2021).

In Stage 1, the relatively low percentage of participants who reported feeling *confident—an* outcome prospective and a positive activating emotion (Pekrun et al. 2023) aligns with the higher percentage who expressed feelings of *insecurity*. This finding probably reflects the way in which the instruction on IBSE was introduced on the first day of a new course module, insofar as the PECTs would have been listening to the tutor's explanations, trying to take on board the information, and likely recalling their previous experiences in science classes, leaving them with their own set of expectations about the novel activities they would be engaging in. This underscores a significant gap in the literature, as most research on emotions in IBSE primarily focuses on secondary school teachers or in-service educators (Davidson et al. 2020; Jaber et al. 2022). In contrast, the present study expands the scope by examining the emotional responses of PECTs. Gaining insight into these responses offers valuable guidance for adapting teacher training programs to better meet the needs of this specific population.

The low percentages for *enjoyment* (positive activating emotion), *dissatisfaction* (negative activating), and *boredom* (negative deactivating), which correspond to emotions based on lived experiences (Pekrun 2014), can be considered expected given that, at this stage, the PECTs had only been introduced to the inquiry-based approach and the content of the instructional module.

Overall, the findings obtained in Stage 1 are consistent with studies that demonstrate positive perceptions of PECTs toward inquiry (Riegle-Crumb et al. 2015). Nevertheless, it is important to note that negative emotions may also play a role as a prerequisite for improvement, as they challenge teacher trainees' perception of themselves as professionals and act as a stimulus for change (Darby 2008). Previous research by Edwards and Loveridge (2011), Riegle-Crumb et al. (2015), and Gerde et al. (2018) suggests that such negative emotions may be influenced by past experiences, initial attitudes toward learning science, and/or a lack of familiarity with the proposed inquiry approach. This unfamiliarity can be perceived as low self-efficacy and might affect PECTs' initial disposition toward this pedagogical method. These findings align with control-value theory (Pekrun and Perry 2014; Pekrun et al. 2023), which emphasizes that emotions such as *insecurity* arise when PECTs perceive low control over new tasks. However, these emotions can serve as drivers of learning when managed appropriately. Specifically, *boredom* is considered a negative valence and activation emotion according to the circumplex model of emotions by Feldman-Barrett and Russell (1998).

6.2 | Emotions in Stages 2 and 3

Importantly, the proportion of PECTs who reported *insecurity* in Stages 2 and 3 of the instruction decreased considerably in relation to Stage 1 (from 29% at the outset to around 17%). However, the most significant finding concerning *insecurity* is the absence of a difference between Stages 2 and 3. In other words, despite undergoing the inquiry cycle in Stage 2, the *insecurity* regarding IBSE practices persisted. To be specific, *insecurity* emerged as the second most prevalent emotion during the phases of designing experiments and choosing variables in Stage 3 (Figure 3). This suggests that PECTs' skills were not fully developed during Stage 2, highlighting their difficulties with these phases of the inquiry cycle (Zoupidis et al. 2023). Put differently, *insecurity*, as both an outcome activity and a negative activating emotion (Pekrun et al. 2023), was not sufficiently effective in triggering the search for solutions during the inquiry. In this context, we must emphasize the importance of PECTs discussing their *insecurity* based on the results of their inquiry (Jaber et al. 2022; Smit et al. 2021). Only in this way can this emotion contribute to learning rather than hinder it (Bellocchi 2018).

These issues underscore the need for instructional designs aligned with NGSS practices (NGSS Lead States 2013) that gradually build PECTs' confidence in designing experiments and selecting variables. Activities that offer structured guidance, such as problem formulation and data analysis, could help reduce *insecurity* and strengthen a sense of achievement. These strategies

would not only better align PECTs training with NGSS practices (NGSS Lead States 2013), but also draw on Pekrun and Perry's (2014) concept that positive activating emotions, such as *confidence* and *enjoyment*, emerge when perceptions of control and value are enhanced during learning tasks.

By contrast, *concentration* remained the third most common choice throughout the instruction. We also found that as our students gained experience in inquiry tasks (whether in the role of science learners or teacher trainees), a higher proportion of them reported experiencing *confidence* and *enjoyment*, a finding consistent with previous studies in this field (Gerde et al. 2018; Riegle-Crumb et al. 2015). *Enjoyment* appears to be particularly associated with conducting experiments and analyzing data, possibly because the PECTs are likely to be more familiar with this kind of practical work through their earlier experience of school science classes (Millar and Abrahams 2009). This progression underscores the importance of incorporating activities in which PECTs can deeply engage with hands-on experiments and data analysis, as highlighted by the NGSS (NGSS Lead States 2013) emphasis on authentic scientific practices. Aligning these practices with reflective opportunities allows PECTs to connect their emotions with the phases of inquiry, fostering a deeper understanding of the inquiry cycle.

Additionally, these findings can be related to the emotional regulation strategies discussed by Uzuntiryaki-Kondakci et al. (2022) in the context of science teachers' emotions. According to these authors, science teachers use specific strategies to manage their emotions, which could positively influence their *enjoyment* and engagement with educational tasks. This underscores the need to support the emotional development and regulation skills of both preservice and experienced teachers, in training as well as professional contexts.

From the perspective of control-value theory (Pekrun and Perry 2014; Pekrun et al. 2023), these findings suggest that promoting emotional regulation skills among PECTs can help them perceive greater control over inquiry-based tasks, thereby transforming potential negative emotions, such as *insecurity*, into positive drivers of *enjoyment* and *confidence*. This is consistent with the findings of this study, where positive and activating emotions, such as *enjoyment* and *confidence*, became more prevalent as PECTs progressed through the phases of inquiry, particularly during stages involving the conduct of experiments and data analysis. Moreover, these results emphasize how emotions can mediate the relationship between the value that PECTs place on scientific inquiry and their ability to engage meaningfully with NGSS-aligned practices (NGSS Lead States 2013).

6.3 | The Role of Negative Emotions in IBSE

The remaining four emotions that were part of the checklist (i.e., *rejection*, *boredom*, *dissatisfaction*, and *shame*), all of which have negative valence (Pekrun et al. 2023), were endorsed by very small numbers of PECTs (less than 3.5% in each case and at all three stages of instruction). These results are consistent with those reported by Jiménez-Liso et al. (2022) regarding the low prevalence of these emotions in students engaged in inquiry-based activities.

The justifications suggest that the negative emotions experienced by the PECTs in Stage 2 may have been influenced not only by the phase itself but also by contextual aspects of the inquiry, such as failing to achieve the desired product or reluctance to taste the yoghurt. This perspective aligns with Schauble et al.'s (1991) ideas on scientific learning, where the focus is on understanding the interactions between theories, data, and explanations during the investigation. In our study, we found that some PECTs may not have fully understood the nature of the inquiry process, and thus, not obtaining a product (such as yoghurt) with the desired characteristics does not necessarily imply a failure in the inquiry. Instead, critically analyzing the product obtained should encourage a reflective evaluation of the procedure and identification of areas for improvement, in line with Schauble et al.'s (1991) view that authentic scientific learning involves learning through reflection on the findings obtained. Additionally, other justifications for negative emotions were the organization of work groups, the significance of the lack of knowledge, the necessity for concentration and argumentation, and the uncertainty surrounding potential outcomes in the scientific inquiry processes.

These results highlight that emotional regulation and the strategic use of NGSS practices (NGSS Lead States 2013) can create a foundation for the long-term engagement of PECTs with IBSE, both in their role as science learners and as teacher trainees.

6.4 | Relationship Between Emotions and Inquiry Cycle Phases

Regarding the prevalence of different emotions at different phases of the inquiry cycle, this peaked during the conduct experiments and collect data phases, where *interest* and *enjoyment* were the most commonly endorsed emotions (this was the case regardless of whether the PECTs were in the science learner or teacher trainee role). Both these phases of inquiry give PECTs the opportunity to develop their practical skills and engage in collaborative learning (Pekrun and Perry 2014; Riegle-Crumb et al. 2015), and in this respect, our results suggest that these kinds of activities are appealing to PECTs (Jiménez-Liso et al. 2022). Another important finding to emerge from the analysis of the emotions experienced at different phases of the inquiry cycle is that our PECTs appeared to have gained *confidence* and were more likely to report *enjoyment* as they reached the end of the cycle (the drawing conclusions phase). The Bevins and Price (2016) model offers a structured approach to inquiry-based experiences, fostering meaningful and autonomous learning among future teachers. By integrating its three dimensions—conceptual, procedural, and personal—it not only promotes mastery of content and research techniques but also cultivates intrinsic motivation, which is crucial for effective teaching in early childhood education. This integrated approach is especially valuable for PECTs training, as it encourages a positive attitude toward scientific learning and strengthens their ability to engage as active participants in the inquiry process.

By contrast, phases that imply the simultaneous application of cognitive and practical skills, namely designing experiments and choosing variables, tended to generate more *insecurity*. This

finding coincides with Palmer's (2009) study, which states that achievement emotions such as *insecurity* are related to planning and decision-making. This could be problematic if this *insecurity* becomes a barrier to learning (Jiménez-Liso et al. 2022) and hinders the utilization of these inquiry phases in their professional practice (Zoupidis et al. 2023).

Additionally, it should be noted that the prevalence of negative emotions was negligible (or even zero) in Stages 2 and 3 of the instruction. However, when analyzing these situations in greater detail and considering Pekrun's terminology (2014), it is observed that when PECTs' results do not meet their expectations, epistemic emotions such as *dissatisfaction* or *rejection* emerge. Consequently, when PECTs express reluctance to try the final product, these emotions can be classified as topics. On the other hand, when they attribute the lack of achievement to poor team organization, it could be categorized as a social emotion.

Furthermore, we have observed that, while in Stage 2 the PECTs had not fully grasped the significance of the inquiry cycle and were unable to attribute their emotions to specific phases of the cycle, this capacity improves in Stage 3. Here, PECTs offer suitable justifications for the emotions they experienced in each phase. Overall, these results support the conclusions reached by Schutz et al. (2009), Frenzel et al. (2018), and Jiménez-Liso et al. (2022) regarding the importance of fostering a classroom emotional climate that builds students' confidence and promotes learning.

7 | Conclusions and Educational Implications

7.1 | Conclusions

In terms of what the PECTs felt prior to actually experiencing the inquiry-based approach to teaching science (RQ1), the results suggest that they were willing to engage with the proposed instruction, even though some of them also felt insecure about what for them was a new approach. Importantly, however, negative emotions such as *dissatisfaction*, *rejection*, *boredom*, or *shame*, which may stifle curiosity or act as barriers to learning, were reported by only a few PECTs. Nevertheless, these emotions can also serve as activators for learning if they are addressed in the classroom within an appropriate emotional climate (Membiela et al. 2022).

This initial *interest* in the inquiry-based approach was maintained throughout Stages 2 and 3 of the instruction (science learner and teacher trainee role), as was the proportion of PECTs who endorsed the *concentration* (RQ2). In addition, the percentage of PECTs who reported experiencing *enjoyment* and *confidence* was notably higher once they actually experienced the inquiry-based approach (Stages 2 and 3 of instruction vs. Stage 1). Although *insecurity* generally became less prevalent as they worked their way through the inquiry cycle in both Stages 2 and 3 (i.e., regardless of whether they were in the science learner or teacher trainee role), it was nonetheless an important emotion during the first three phases of inquiry (i.e., formulate problem, design experiments, choose variables), especially when they were in the teacher trainee role. A number of differences between the science learner and teacher trainee role stages of instruction are also observable if we consider the emotions experienced at different phases of inquiry. Thus, the proportion of PECTs who endorsed the emotion of *interest* in relation to the data collection phase was notably higher when they were in the science learner role (Stage 2), whereas the same activity produced greater *enjoyment* when in the teacher trainee role. Differences of this kind were also found in relation to the data collection and drawing conclusions phases for *concentration* (more prevalent in the science learner role) and *insecurity* (barely present during these phases in the teacher trainee role). Despite being below 3.5%, the PECTs also exhibited *dissatisfaction*, *rejection*, *boredom*, and *shame*, which are considered negative emotions in the learning process, although they could activate certain stages of the inquiry process.

It should also be noted that in both Stages 2 and 3 of the instruction (science learner and teacher trainee role), the emotions experienced by the PECTs varied across the different phases of inquiry (RQ3). When engaging with the inquiry approach in the role of science learners (Stage 2), some emotions appeared to be related to several inquiry phases, while others were associated with just one. By contrast, in the teacher trainee role (Stage 3) all the emotions considered were associated with more than one phase. This suggests that when our students adopted the role of teacher trainees and were required to design inquiry tasks for use in the classroom, they experienced a broader range of emotions throughout the inquiry cycle. In both the science learner and teacher trainee roles, *insecurity* was generally associated with the initial phases of inquiry (problem formulation, designing experiments, and choosing variables); *enjoyment* was more prevalent during the following phases; and *confidence* was particularly associated with the final phases (data collection and drawing conclusions). As regards *concentration*, this was most closely associated with choosing variables when our PECTs were in the science learner role, whereas when they adopted the role of teacher trainee, the same emotion was associated with problem formulation, conducting experiments, and analyzing data. Similarly, *enjoyment* was associated more with conducting experiments and analyzing data when our PECTs were in the science learner role, whereas in the teacher trainee role it was more closely linked to data collection and drawing conclusions. Overall, these results suggest that in order to understand PECTs' emotions in relation to IBSE, it is necessary to consider the different phases of inquiry, each of which may generate a different emotional response.

7.2 | Study Limitations

The results of this study provide some insight into the emotions that PECTs experience during instruction in IBSE, showing how what they feel may vary depending on the phase of the inquiry cycle and the task demands (i.e., whether they are engaging with inquiry tasks in the role or science learners or teacher trainees).

We believe that while the study addresses a gap in the field regarding how PECTs start to feel about inquiry, additional details, data sources, and analyses are needed to provide a more nuanced understanding of the PECTs' emotions during moments of learning and designing inquiry activities. Nonetheless,

a primary limitation of our study concerns the instrument used to gather data on emotions: the PECTs could only choose from among the nine emotions included in the checklist, and the results obtained tell us nothing about the intensity of the emotions they endorsed. Therefore, it is essential to enhance this research with a more qualitative approach by incorporating additional instruments such as interviews. With data of this nature, it would be possible to make progress in understanding the reasons why certain emotions appear unequally across different phases of the inquiry and the roles played by the PECTs (both science learners and teacher trainees).

Another limitation is the small sample size, consisting of PECTs from only two class groups within the same university. Consequently, the conclusions of this study are specific to the context of a single country (Spain) and reflect a particular approach to scientific inquiry in the initial training of early childhood education teachers, which may differ depending on teacher training curricula in other countries.

A further limitation concerns the fact that the results cannot be interpreted independently of our instructional module, that is to say, we analyzed the emotions experienced in relation to the different phases of a specific inquiry cycle. It is therefore unclear to what extent our findings may be generalizable to other settings or to instruction built around inquiry cycles of different characteristics. Additionally, and as noted earlier, it is important to remember that the scatterplots derived from the analysis of stacked tables only show the association between inquiry phases and emotions, not the relationship between phases.

Finally, it is essential to take into account that the conclusions of this study may be affected by the contextual factors of the inquiry sequence used in Stage 2. For instance, some of the negative emotions were closely tied to the product they had to obtain and its tasting. Different inquiry sequences of varying natures could evoke a distinct range of emotions.

7.3 | Educational Implications

Overall, the results obtained suggest that the PECTs felt emotionally engaged with the instruction in IBSE. Furthermore, the primary emotions evoked were those considered necessary to encourage learning of this approach (Jiménez-Liso et al. 2022). The findings also highlight the unique emotional responses of PECTs, a sample that has been little studied in the context of IBSE.

The extent to which the PECTs have assimilated the ideas they were taught must now be explored further by requiring them to design new inquiry-based activities for use in early childhood education. Additionally, it is essential to continue providing PECTs with opportunities to experience inquiry-based learning throughout their training (Erden and Sönmez 2011; Gerde et al. 2018; Hamlin and Wisneski 2012) promoting the role that emotions play in it.

The findings also suggest that when providing PECTs with instruction in IBSE, particular attention should be paid to certain phases of the inquiry process. For example, they may need greater support with problem formulation (framing the research question) and the design of simple experiments that enable them to understand the difference between different types of variables (independent, dependent, control), especially when they are engaging with inquiry tasks in the role of teacher trainee. In this respect, a primary goal of future research is to examine the extent to which—and in what form—PECTs make use of an inquiry-based approach to teaching science once they enter professional practice and also to explore the emotions they experience when doing so.

Regarding the emotions expressed by the PECTs, *confidence* and *insecurity*—both identified as key emotions—can be addressed in initial teacher training programs by incorporating reflective practices and fostering peer collaboration in inquiry-based learning. The justifications behind the negative emotions reveal essential aspects that warrant consideration during inquiry-based training, especially concerning emotional support for PECTs. It is important to assist teacher trainees in recognizing, labeling, and valuing the emotions they experience during the inquiry process. This support can extend to helping them guide their future young learners in validating and embracing such emotions. For instance, since *insecurity* appears to be a normal and generative component of scientific processes, PECTs should understand that uncertainty about potential outcomes is inherent in scientific work (Kampourakis and McCain 2019) and that unfavorable findings can also produce useful information (Schauble et al. 1991). Therefore, it is essential to make PECTs aware that negative emotions, such as *insecurity*, can serve as opportunities for learning and professional growth (Bellocchi 2018), as they can also promote resilience and self-reflection, as well as deeper questioning that allows PECTs to explore new perspectives. Additionally, concentration and the ability to construct arguments are equally crucial components of the scientific process. Therefore, in line with Schauble et al.'s (1991) proposal, during instruction, PECTs should be encouraged to verbalize their predictions and justify their conclusions with questions such as "What do you think will happen?" or "How do you know?" Since PECTs do not spontaneously ask themselves these questions, it would be beneficial to incorporate opportunities for them throughout the training process.

Another implication is related to the fact that recently, science education has highlighted multiple epistemologies for science, rejecting the idea that there is a single correct scientific method (Warren et al. 2020). Thus, emotions like *insecurity* could stem from PECTs not identifying with "the" scientific method presented in their university setting (or in earlier experiences with school), which is an area of interest for future research.

In light of these findings, it is essential to consider the broader implications of emotional engagement in IBSE. Although this research focuses on PECTs, we believe that emotional engagement plays a crucial role in IBSE from K1 to K12. While the NGSS (NGSS Lead States 2013) does not explicitly address emotions as a separate component within the standards, they are inherently woven into scientific and engineering practices through the emphasis on inquiry. As students engage in hands-on activities, problem-solving, and the exploration of meaningful scientific questions, emotions naturally emerge as an integral part of the learning process. Practical activities aligned with the NGSS

(NGSS Lead States 2013) not only strengthen scientific skills but also shape students' emotional connection to science, helping to overcome barriers such as *insecurity* and fostering deeper, more meaningful learning experiences. Therefore, it is essential for educators to recognize the significance of emotions in inquiry-based learning and to cultivate a supportive classroom environment that encourages emotional engagement (Bellocchi 2018).

Acknowledgments

This work is part of the R&D&i Project "Citizens with Critical Thinking: A Challenge for Teachers in Science Education," reference PID2019-105765GA-I00, funded by the Ministerio de Ciencia e Innovación and the Agencia Estatal de Investigación of the Spanish Government (grant number MCIN/AEI/10.13039/501100011033). Open access funding provided by Universidad de Málaga / CBUA. [Correction added after first online publication on 26 June 2025. Acknowledgements has been updated.]

Ethics Statement

The study was conducted in accordance with the protocol approved by the Ethics Committee on Experimentation of the University of Málaga (Spain) (CEUMA) with reference 31-2022-H.

References

Alarcón-Orozco, M. M., A. J. Franco-Mariscal, and A. Blanco-López. 2021. "Feria de experiencias de indagación en ciencias en la formación inicial de maestros de educación. [Inquiry in Science Experience Fair in Initial Teacher Education.]." In *Enseñanza de las ciencias y problemas relevantes de la ciudadanía. Transferencia al aula. [Science Education and Relevant Citizenship Issues. Transfer to the Classroom.]*, edited by D. Cebrián-Robles, A. J. Franco-Mariscal, T. Lupión-Cobos, M. C. Acebal-Expósito, and A. Blanco-López, 173–188. Graó.

Anderson, A. K. 2005. "Affective Influences on the Attentional Dynamics Supporting Awareness." *Journal of Experimental Psychology: General* 2: 258–281.

Antonio, V. V. 2018. "Science Laboratory Interest and Preferences of Teacher Education Students: Implications to Science Teaching." *Asia Pacific Journal of Multidisciplinary Research* 6, no. 3: 57–67.

Bellocchi, A. 2015. "Methods for Sociological Inquiry on Emotion in Educational Settings." *Emotion Review* 7, no. 2: 151–156. https://doi.org/10.1177/1754073914554775.

Bellocchi, A. 2018. "Negative Emotional Events During Science Inquiry." In *Eventful Learning: Learner Emotions*, Bold Visions in Educational Research, edited by K. Tobin and S. M. Ritchie, vol. 61, 87–104. Brill.

Bellocchi, A., S. M. Ritchie, K. Tobin, D. King, M. Sandhu, and S. Henderson. 2014. "Emotional Climate and High Quality Learning Experiences in Science Teacher Education." *Journal of Research in Science Teaching* 51, no. 10: 1301–1325. https://doi.org/10.1002/tea.21170.

Bevins, S., and G. Price. 2016. "Reconceptualising Inquiry in Science Education." *International Journal of Science Education* 38, no. 1: 17–29. https://doi.org/10.1080/09500693.2015.1124300.

Brenneman, K. 2011. "Assessment for Preschool Science Learning and Learning Environments." *Early Childhood Research and Practice* 13, no. 1: 1.

Brenneman, K., J. Stevenson-Boyd, and E. Frede. 2009. "Math and Science in Preschool: Policies and Practice." *Preschool Policy Brief* 19: 1–12.

Charmaz, K. 2006. *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. Sage Publications.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Science*. 2nd ed. Erlbaum.

Cohen, J. 1992. "Quantitative Methods in Psychology: A Power Primer." *Psychological Bulletin* 112: 1155–1159. https://doi.org/10.1037/0033-2909.112.1.155.

Cruz-Guzmán, M., and E. Martínez. 2022. "Iniciación a Las prácticas científicas en Educación Infantil: Aprendiendo Sobre el Sistema Digestivo Por indagación Basada en Modelos [Introducing Early Childhood Learners to Science in Practice: Learning About the Digestive System Through Model-Based Inquiry]." *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* 19, no. 1: 120201–120220. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2022.v19.i1.1202.

Darby, A. 2008. "Teachers' Emotions in the Reconstruction of Professional Self-Understanding." *Teaching and Teacher Education* 24, no. 5: 1160–1172. https://doi.org/10.1016/j.tate.2007.02.001.

David, P., and A. Bellocchi. 2018. "Objectivity, Subjectivity, and Emotion in School Science Inquiry." *Journal of Research in Science Teaching* 55, no. 10: 1419–1447. https://doi.org/10.1002/tea.21461.

Davidson, R. J., and S. Begley. 2012. *The Emotional Life of Your Brain*. Hudson Street Press.

Davidson, S. G., L. Z. Jaber, and S. A. Southerland. 2020. "Emotions in the Doing of Science: Exploring Epistemic Affect in Elementary Teachers' Science Research Experiences." *Science Education* 104, no. 6: 1008–1040. https://doi.org/10.1002/sce.21596.

Davidson, S. G., L. Z. Jaber, and S. A. Southerland. 2022. "Cultivating Science Tachers' Understandings of Science as a Discipline." *Science & Education* 31: 657–683. https://doi.org/10.1007/s11191-021-00276-1.

De la Calle, C. 2005. "Proyecto el agua. Escuela Infantil Los Gorriones." [Water Project. Los Gorriones Preschool]. https://www.csicenlaescuela.csic.es/proyectos/flotacion/experiencias/web/a1.htm.

Dorio, I., M. Sabariego, and I. Massot. 2004. "Características generales de la metodología cualitativa. [A General Introduction to Qualitative Methods]." In *Metodología de la investigación educativa [Educational Research Methods]*, edited by R. Bisquerra, 275–292. La Muralla.

Edwards, K., and J. Loveridge. 2011. "The Inside Story: Looking Into Early Childhood Teachers' Support of Children's Scientific Learning." *Australian Journal of Early Childhood* 36, no. 2: 28–35. https://doi.org/10.1177/183693911103600205.

Erden, F. T., and S. Sönmez. 2011. "Study of Turkish Preschool Teachers' Attitudes Toward Science Teaching." *International Journal of Science Education* 33, no. 8: 1149–1168. https://doi.org/10.1080/09500693.2010.511295.

Eshach, H., and M. N. Fried. 2005. "Should Science Be Taught in Early Childhood?" *Journal of Science Education and Technology* 14, no. 3: 315–336. https://doi.org/10.1007/s10956-005-7198-9.

European Commission, Directorate-General for Research and Innovation. 2007. *Science Education NOW: A Renewed Pedagogy for the Future of Europe*. Publications Office. https://bit.ly/2UNz86M.

European Commission, Directorate-General for Research and Innovation. 2015. *Science Education for Responsible Citizenship. Report to the European Commission of the Expert Group on Science Education*. Publications Office. https://data.europa.eu/doi/10.2777/12626.

Feldman-Barrett, L., and J. A. Russell. 1998. "Independence and Bipolarity in the Structure of Current Affect." *Journal of Personality and Social Psychology* 74, no. 4: 967–984. https://doi.org/10.1037/0022-3514.74.4.967.

Fischer, K. W. 2012. "Starting Well: Connecting Research With Practice in Preschool Learning." *Early Education and Development* 23, no. 1: 131–137. https://doi.org/10.1080/10409289.2012.63787.

Franco-Mariscal, A. J., ed. 2024. *Critical Thinking in Science Education and Teacher Training*. Springer. https://doi.org/10.1007/978-3-031-78578-8.

French, L. 2004. "Science as the Center of a Coherent, Integrated Early Childhood Curriculum." *Early Childhood Research Quarterly* 19, no. 1: 138–149. https://doi.org/10.1016/j.ecresq.2004.01.004.

Frenzel, A. C., B. Becker-Kurz, R. Pekrun, T. Goetz, and O. Lüdtke. 2018. "Emotion Transmission in the Classroom Revisited: A Reciprocal Effects Model of Teacher and Student Enjoyment." *Journal of Educational Psychology* 110, no. 5: 628–639. https://doi.org/10.1037/edu0000228.

Gerde, H. K., S. J. Pierce, K. Lee, and L. A. Van Egeren. 2018. "Early Childhood Educators' Self-Efficacy in Science, Math, and Literacy Instruction and Science Practice in the Classroom." *Early Education and Development* 29, no. 1: 70–90. https://doi.org/10.1080/10409289.2017.1360127.

Gilbert, J., A. Bulte, and A. Pilot. 2011. "Concept Development and Transfer in Context-Based Science Education." *International Journal of Science Education* 33, no. 11: 817–837. https://doi.org/10.1080/09500693.2010.493185.

Greenacre, M. 2017. *Correspondence Analysis in Practice*. 3rd ed. Chapman and Hall/CRC. https://doi.org/10.1201/9781315369983.

Gropen, J., N. Clark-Chiarelli, C. Hoisington, and S. B. Ehrlich. 2011. "The Importance of Executive Function in Early Science Education." *Child Development Perspectives* 5, no. 4: 298–304. https://doi.org/10.1111/j.1750-8606.2011.00201.x.

Gropen, J., J. F. Kook, C. Hoisington, and N. Clark-Chiarelli. 2017. "Foundations of Science Literacy: Efficacy of a Preschool Professional Development Program in Science on Classroom Instruction, Teachers' Pedagogical Content Knowledge, and Children's Observations and Predictions." *Early Education and Development* 28, no. 5: 607–631. https://doi.org/10.1080/10409289.2017.1279527.

Hamlin, M., and D. B. Wisneski. 2012. "Supporting the Scientific Thinking and Inquiry of Toddlers and Preschoolers Through Play." *Young Children* 67, no. 3: 82–88.

Hill, C. E., S. Knox, B. J. Thompson, E. N. Williams, S. A. Hess, and N. Ladany. 2005. "Consensual Qualitative Research: An Update." *Journal of Counseling Psychology* 52, no. 2: 196–205. https://doi.org/10.1037/0022-0167.52.2.196.

Immordino-Yang, M. H., L. Darling-Hammond, and C. R. Krone. 2019. "Nurturing Nature: How Brain Development Is Inherently Social and Emotional, and What This Means for Education." *Educational Psychologist* 54, no. 3: 185–204. https://doi.org/10.1080/00461520.2019.1633924.

Jaber, L. Z., V. Dini, and D. Hammer. 2022. "Well That's How the Kids Feel!—Epistemic Empathy as a Driver of Responsive Teaching." *Journal of Research in Science Teaching* 59, no. 2: 223–251. https://doi.org/10.1002/tea.21726.

Jiménez-Liso, M. R., A. Bellocchi, M. Martínez-Chico, and R. López-Gay. 2022. "A Model-Based Inquiry Sequence as a Heuristic to Evaluate Students' Emotional, Behavioural, and Cognitive Engagement." *Research in Science Education* 52: 1313–1334. https://doi.org/10.1007/s11165-021-10010-0.

Jiménez-Liso, M. R., M. Martínez, L. Avraamidou, and R. López-Gay. 2021. "Scientific Practices in Teacher Education: The Interplay of Sense, Sensors, and Emotions." *Research in Science & Technological Education* 39, no. 1: 44–67. https://doi.org/10.1080/02635143.2019.1647158.

Kampourakis, K., and K. McCain. 2019. *Uncertainty: How It Makes Science Advance*. Oxford University Press. https://doi.org/10.1093/oso/9780190871666.001.0001.

King, D., S. Ritchie, M. Sandhu, and S. Henderson. 2015. "Emotionally Intense Science Activities." *International Journal of Science Education* 37, no. 12: 1886–1914. https://doi.org/10.1080/09500693.2015.1055850.

Larimore, R. A. 2020. "Preschool Science Education: A Vision for the Future." *Early Childhood Education Journal* 48: 703–714. https://doi.org/10.1007/s10643-020-01033-9.

Lederman, N. G., J. S. Lederman, and A. Antink. 2013. "Nature of Science and Scientific Inquiry as Contexts for Learning of Science and Achievement of Scientific Literacy." *International Journal of Education in Mathematics, Science and Technology* 1, no. 3: 138–147.

Lee, C. K., and M. Shea. 2016. "An Analysis of Pre-Service Elementary Teachers' Understanding of Inquiry-Based Science Teaching." *Science Education International* 27, no. 2: 217–237.

Linnenbrink, E. A., and P. R. Pintrich. 2002. "Achievement Goal Theory and Affect: An Asymmetrical Bidirectional Model." *Educational Psychologist* 37, no. 2: 69–78. https://doi.org/10.1207/S15326985EP3702_2.

Llewellyn, D. 2001. *Inquire Within: Implementing Inquiry-Based Science Standards*. Corwin Press.

Magee, P., and R. Flessner. 2012. "Collaborating to Improve Inquiry-Based Teaching in Elementary Science and Mathematics Methods Courses." *Science Education International* 23, no. 4: 353–365.

Marcos-Merino, J. M. 2019. "Análisis de Las Relaciones Emociones-Aprendizaje de Maestros en formación Inicial Con Una práctica Activa de Biología [Analysis of Emotion-Learning Relationships in Preservice Teachers During a Practical Biology Activity]." *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* 16, no. 1: 1603. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2019.v16.i1.1603.

Martínez-Chico, M., M. Evagorou, and M. R. Jiménez-Liso. 2020. "Design of a Pre-Service Teacher Training Unit to Promote Scientific Practices. Is a Chickpea a Living Being?" *International Journal of Designs for Learning* 11, no. 1: 21–30. https://doi.org/10.14434/ijdl.v11i1.23757.

Mauss, I., and M. Robinson. 2009. "Measures of Emotion: A Review." *Cognition and Emotion* 23, no. 2: 209–237. https://doi.org/10.1080/02699930802204677.

McNerney, K., and N. Hall. 2017. "Developing a Framework of Scientific Enquiry in Early Childhood: An Action Research Project to Support Staff Development and Improve Science Teaching." *Early Child Development and Care* 187, no. 2: 206–220. https://doi.org/10.1080/03004430.2016.1237564.

Mellado, V., A. B. Borrachero, M. Brígido, et al. 2014. "Las emociones en la enseñanza de las ciencias [Emotions in Science Teaching]." *Enseñanza de Las Ciencias* 32, no. 3: 11–36. https://doi.org/10.5565/rev/ensciencias.1478.

Membiela, P., M. Vidal, S. Fragueiro, et al. 2022. "Motivation for Science Learning as an Antecedent of Emotions and Engagement in Preservice Elementary Teachers." *Science Education* 106, no. 1: 119–141. https://doi.org/10.1002/sce.21686.

Millar, R., and I. Abrahams. 2009. "Practical Work: Making It More Effective." *School Science Review* 91, no. 334: 59–64.

Monteira, S. F., and M. P. Jiménez-Aleixandre. 2016. "The Practice of Using Evidence in Kindergarten: The Role of Purposeful Observation." *Journal of Research in Science Teaching* 53, no. 8: 1232–1258. https://doi.org/10.1002/tea.21259.

Morales, M., K. Acosta, and C. Rodríguez. 2022. "El rol docente y la indagación científica: análisis de una experiencia sobre plagas en una escuela vulnerable de Chile [The Teaching Role and Scientific Inquiry: Analysis of Instruction on Pest Control for Students in a Vulnerable Rural Area of Chile]." *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* 19, no. 2: 22010–22028. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2022.v19.i2.2201.

Muñoz-Campos, V., A. J. Franco-Mariscal, and A. Blanco-López. 2020. "Integration of Scientific Practices Into Daily Living Contexts: A Framework for the Design of Teaching-Learning Sequences." *International Journal of Science Education* 42, no. 15: 2574–2600. https://doi.org/10.1080/09500693.2020.1821932.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, by States*. National Academies Press. https://doi.org/10.17226/18290.

NRC (National Research Council). 1996. *The National Science Education Standards*. National Academies Press.

NRC (National Research Council). 2000. *Inquiry and the National Science Education Standards. A Guide for Teaching and Learning*. National Academies Press.

NRC (National Research Council). 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Academies Press. https://doi.org/10.17226/13165.

OECD. 2016. *PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic and Financial Literacy*. OECD Publishing.

Olitsky, S., and C. Milne. 2012. "Understanding Engagement in Science Education: The Psychological and the Social." In *Second International Handbook of Science Education*, edited by B. Fraser, K. Tobin, and C. McRobbie, 19–33. Springer. https://doi.org/10.1007/978-1-4020-9041-7_2.

Osborne, J., and J. Dillon. 2008. *Beyond 2000: Science Education for the Future*. Nuffield Foundation.

Palmer, D. H. 2009. "Student Interest Generated During an Inquiry Skills Lesson." *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching* 46, no. 2: 147–165. https://doi.org/10.1002/tea.20263.

Parasuraman, R., and D. R. Davies, eds. 1984. *Varieties of Attention*. Vol. 40, 47–52. Academic Press.

Parra, R. A. 2012. "Yogur en la Salud Humana [Yogurt and Human Health]." *Revista Lasallista de investigación* 9, no. 2: 162–177.

Patton, M. Q. 2002. *Qualitative Research and Evaluation Methods*. Sage.

Pedaste, M., M. Mäeots, L. A. Siiman, et al. 2015. "Phases of Inquiry-Based Learning: Definitions and the Inquiry Cycle." *Educational Research Review* 14: 47–61. https://doi.org/10.1016/j.edurev.2015.02.003.

Pekrun, R. 2005. "Progress and Open Problems in Educational Emotion Research." *Learning and Instruction* 15, no. 5: 497–506. https://doi.org/10.1016/j.learninstruc.2005.07.014.

Pekrun, R. 2014. "Emotions and Learning." In *Educational Practices Series*, edited by S. Vosniadou, vol. 24. International Bureau of Education UNESCO.

Pekrun, R., A. J. Elliot, and M. A. Maier. 2009. "Achievement Goals and Achievement Emotions: Testing a Model of Their Joint Relations With Academic Performance." *Journal of Educational Psychology* 101, no. 1: 115–135. https://doi.org/10.1037/a0013383.

Pekrun, R., T. Goetz, W. Titz, and R. P. Perry. 2002. "Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research." *Educational Psychologist* 37, no. 2: 91–105. https://doi.org/10.1207/S15326985EP3702_4.

Pekrun, R., and L. Linnenbrink-García. 2012. "Academic Emotions and Student Engagement." In *Handbook of Research on Student Engagement*, edited by S. L. Christenson, A. L. Reschly, and C. Wylie, 259–282. Springer. https://doi.org/10.1007/978-1-4614-2018-7_12.

Pekrun, R., and L. Linnenbrink-García, eds. 2014. *International Handbook of Emotions in Education*. 1st ed. Routledge/Taylor & Francis Group. https://doi.org/10.4324/9780203148211.

Pekrun, R., H. W. Marsh, A. J. Elliot, et al. 2023. "A Three-Dimensional Taxonomy of Achievement Emotions." *Journal of Personality and Social Psychology: Personality Processes and Individual Differences* 124, no. 1: 145–178. https://doi.org/10.1037/pspp0000448.

Pekrun, R., and R. P. Perry. 2014. "Control-Value Theory of Achievement Emotions." In *International Handbook of Emotions in Education*, edited by R. Pekrun and L. Linnenbrink-García, 120–141. Routledge/Taylor & Francis Group.

Pendergast, E., R. G. Lieberman-Betz, and C. O. Vail. 2017. "Attitudes and Beliefs of Prekindergarten Teachers Toward Teaching Science to Young Children." *Early Childhood Education Journal* 45: 43–52. https://doi.org/10.1007/s10643-015-0761-y.

Peterson, R. F., and D. F. Treagust. 1998. "Learning to Teach Primary Science Through Problem-Based Learning." *Science Education* 82, no. 2: 215–237. https://doi.org/10.1002/(SICI)1098-237X(199804)82:2<215::AID-SCE6>3.0.CO;2-H.

Ramanathan, G., D. Carter, and J. A. Wenner. 2022. "Framework for Scientific Inquiry in Preschool." *Early Childhood Education Journal* 50: 1263–1277. https://doi.org/10.1007/s10643-021-01259-1.

Reeve, J. 2013. "How Students Create Motivationally Supportive Learning Environments for Themselves: The Concept of Agentic Engagement." *Journal of Educational Psychology* 105, no. 3: 579–595.

Riegle-Crumb, C., K. Morton, C. Moore, A. Chimonidou, C. Labrake, and S. Kopp. 2015. "Do Inquiring Minds Have Positive Attitudes? The Science Education of Preservice Elementary Teachers." *Science Education* 99, no. 5: 819–836. https://doi.org/10.1002/sce.21177.

Robertson, A. D., L. J. Atkins, D. M. Levin, and J. Richards. 2015. "What Is Responsive Teaching?" In *Responsive Teaching in Science and Mathematics*, edited by A. D. Robertson, R. E. Scherr, and D. Hammer, 19–53. Routledge.

Rodríguez-Melero, A. M., M. J. Cáceres-Ruiz, and A. J. Franco-Mariscal. 2021. "¿Cómo Hacemos Crecer Una Planta? Una indagación Con niños de 3 años de educación Infantil. [How Do We Grow a Plant? An Inquiry With 3-Year-Olds.]." *Enseñanza de Las Ciencias* 39, no. 3: 231–253. https://doi.org/10.5565/rev/ensciencias.3345.

Romero-Ariza, M. 2017. "El Aprendizaje Por indagación, ¿Existen Suficientes Evidencias Sobre Sus Beneficios en la enseñanza de Las Ciencias? [Inquiry-Based Learning: What Is the Evidence for Its Benefits in Teaching Science?]." *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* 14, no. 2: 286–299. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2017.v14.i2.01.

Rönnebeck, S., S. Bernholt, and M. Ropohl. 2016. "Searching for a Common Ground: A Literature Review of Empirical Research on Scientific Inquiry Activities." *Studies in Science Education* 52, no. 2: 161–197. https://doi.org/10.1080/03057267.2016.1206351.

Samarapungavan, A., P. Mantzicopoulos, and H. Patrick. 2008. "Learning Science Through Inquiry in Kindergarten." *Science Education* 92, no. 5: 868–908. https://doi.org/10.1002/sce.20275.

Samarapungavan, A., H. Patrick, and P. Mantzicopoulos. 2011. "What Kindergarten Students Learn in Inquiry-Based Science Classrooms." *Cognition and Instruction* 29, no. 4: 416–470. https://doi.org/10.1080/07370008.2011.608027.

Schauble, L., L. E. Klopfer, and K. Raghavan. 1991. "Students' Transition From an Engineering Model to a Science Model of Experimentation." *Journal of Research in Science Teaching* 28, no. 9: 859–882. https://doi.org/10.1002/tea.3660280910.

Scherer, K. R., and A. Moors. 2019. "The Emotion Process: Event Appraisal and Component Differentiation." *Annual Review of Psychology* 70, no. 1: 719–745. https://doi.org/10.1146/annurev-psych-122216-011854.

Scherer, K. R., V. Shuman, J. R. J. Fontaine, and C. Soriano. 2013. "The GRID Meets the Wheel: Assessing Emotional Feeling via Self-Report." In *Components of Emotional Meaning: A Sourcebook*, edited by J. R.

J. Fontaine, K. R. Scherer, and C. Soriano. Oxford University Press. https://doi.org/10.13140/RG.2.1.2694.6406.

Schutz, P., and R. Pekrun. 2007. *Emotion in Education*. Academic Press.

Schutz, P. A., L. P. Aultman, and M. R. Williams-Johnson. 2009. "Educational Psychology Perspectives on Teachers' Emotions." In *Advances in Teacher Emotion Research: The Impact on Teachers' Lives*, edited by P. A. Schutz and M. Zembylas, 195–212. Springer.

Shuman, V., and K. R. Scherer. 2015. "Emotions, Psychological Structure of." In *International Encyclopedia of the Social & Behavioral Sciences*, edited by J. D. Wright, vol. 7, 2nd ed., 526–533. Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.25007-1.

Sinatra, G. M., S. H. Broughton, and D. Lombardi. 2014. "Emotions in Science Education." In *International Handbook of Emotions in Education*, edited by R. Pekrun and L. Linnenbrink-Garcia, 415–436. Routledge, Taylor & Francis Group.

Sjøberg, S. 2019. "Critical Perspectives on Inquiry-Based Science Education (IBSE) in Europe." In *Position Paper Written for the EUN Partnership*. European Schoolnet. https://www.academia.edu/38491775.

Smit, R., N. Robin, and F. Rietz. 2021. "Emotional Experiences of Secondary Pre-Service Teachers Conducting Practical Work in a Science Lab Course: Individual Differences and Prediction of Teacher Efficacy." *Disciplinary and Interdisciplinary Science Education Research* 3, no. 5: 1–17. https://doi.org/10.1186/s43031-021-00034-x.

Spanish Ministry of Education and Vocational Training. 2022. "Royal Decree 95/2022, of 1 February, Establishing Regulations and the Core Curriculum for Early Childhood Education." (B.O.E. núm. 28, 02/02/2022).

Uzuntiryaki-Kondakci, E., Z. D. Kirbulut, O. Oktay, and E. Sarici. 2022. "A Qualitative Examination of Science Teachers' Emotions, Emotion Regulation Goals and Strategies." *Research in Science Education* 52, no. 3: 1131–1155. https://doi.org/10.1007/s11165-020-09986-y.

Warren, B., S. Vossoughi, A. S. Rosebery, M. Bang, and E. V. Taylor. 2020. "Multiple Ways of Knowing: Re-Imagining Disciplinary Learning." In *Handbook of the Cultural Foundations of Learning*, edited by N. S. Nasir, C. D. Lee, R. Pea, and M. de McKinney Royston, 277–294. Routledge.

Wilder, O., M. B. Butler, P. Acharya, and M. Gill. 2019. "Preservice Elementary Science Teacher Attitudes Matter: A New Instrument on Positive Affect Toward Science." *Journal of Science Teacher Education* 30, no. 6: 601–620. https://doi.org/10.1080/1046560X.2019.1589849.

Worth, K. 2010. "Science in Early Childhood Classrooms: Content and Process." *Early Childhood Research & Practice (ECRP)* 12, no. 2: 1–17.

Yeigh, T., G. Woolcott, J. Donnelly, R. Whannell, M. Snow, and A. Scott. 2016. "Emotional Literacy and Pedagogical Confidence in Pre-Service Science and Mathematics Teachers." *Australian Journal of Teacher Education* 41, no. 6: 107–121. https://doi.org/10.14221/ajte.2016v41n6.

Zoupidis, A., V. Tselfes, and P. Kariotoglou. 2023. "Preservice Early Childhood Teachers' Beliefs That Influence Their Intention to Use Inquiry-Based Learning Methods." *International Journal of Early Years Education* 31, no. 3: 738–752. https://doi.org/10.1080/09669760.2021.1890552.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.