Received: 11 December 2020 | Revised: 12 August 2021 | Accepted: 19 August 2021

DOI: 10.1002/sce.21686

SCIENCE TEACHER EDUCATION

Science Education WILEY

Motivation for science learning as an antecedent of emotions and engagement in preservice elementary teachers

Pedro Membiela[1] | Manuel Vidal[1] | Sandra Fragueiro[2] | María Lorenzo[3] | Isabel García-Rodeja[4] | Virginia Aznar[5] | Anxela Bugallo[6] | Antonio González[1]

[1]Facultade de Educación e Traballo Social, Universidade de Vigo, Ourense, Spain

[2]E. U. de Profesorado María Sedes Sapientiae, Universidade de Vigo, Vigo, Spain

[3]Facultade de Ciencias da Educación e do Deporte, Universidade de Vigo, Pontevedra, Spain

[4]Facultade de Ciencias da Educación, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

[5]Facultade de Formación do Profesorado, Universidade de Santiago de Compostela, Lugo, Spain

[6]Facultade de Ciencias da Educación, Universidade da Coruña, A Coruña, Spain

Correspondence

Pedro Membiela, Facultade de Educación e Traballo Social, Universidade de Vigo, Avda Castelao, Ourense 32004, Spain.
Email: membiela@uvigo.es

Abstract

Several variables associated with motivation toward science learning in preservice elementary teachers, such as relevance to personal goals and self-efficacy, are important factors in preservice preparation. The main objective is to analyze the relationships of these motivational variables with the emotions of boredom and enjoyment, and with engagement in science learning. Data were obtained with a self-report questionnaire completed by 871 preservice elementary teachers and analyzed using the structural equation model (SEM) methodology. The first step determined the adequacy of the measurement model and, in the second step, SEM showed that the variables associated with motivation for science learning significantly predicted the variance of boredom and enjoyment as 27% and 52%, respectively. The variables associated with motivation for science learning and emotions explained 67% of the variance in science learning engagement. Relevance to personal goals and self-efficacy in science learning predicted the emotional variables. Emotional variables mediated the impact of motivational variables in science-learning engagement. The fundamental role of emotions in motivation and science-learning engagement in preservice elementary teachers is observed.

KEYWORDS
emotions, engagement, motivation, preservice elementary teachers, science learning

1 | INTRODUCTION

Engagement is currently one of the key issues in education from an affective perspective (Grabau & Ma, 2017). In this regard, engagement in science has been defined (OECD, 2009) and evaluated within the framework of the PISA 2006 project (OECD, 2007). Understanding engagement in science learning and its determinants is essential to promoting science learning after compulsory education, such as in the case of preservice elementary teachers during their science teaching preparation.

Science continues to be a neglected and low-priority subject in the curricula of primary education (Appleton & Kindt, 2002; NRC, 2012). However, teachers who promote knowledge and attitude toward science in students are key to student success also at the elementary levels (Rennie et al., 2001). In this sense, the problems of science learning in primary education (Appleton & Kindt, 2002) are associated with teacher confidence, attitude, and knowledge (Keys, 2006).

A large study carried out in Australian schools (Rennie et al., 2001) indicated that science taught in primary schools is focused on students and activities, but in secondary schools, science is not relevant nor engaging and does not respond to students' interests and experiences. Consequently, this disenchantment is observed as a decrease in choice of science subjects by secondary school students. This problem seems to be related to the fact that many preservice primary teachers have negative attitudes toward science and perceive little self-efficacy in science teaching (Fulp, 2002).

The well-being of teachers and students and proper functioning of classroom are related to motivation, emotions, and engagement of teachers and students, where emotions play an important role (Pekrun et al., 2018). Therefore, emotions should be included when analyzing teacher preparation, since they can contribute to the development of cognitive and emotionally competent teachers (Eren, 2014).

Hence, this study examines the relationships between motivation, emotions, and engagement of preservice elementary teachers when learning science, to improve our knowledge of this little known but important teacher preparation issue.

2 | THEORETICAL FOUNDATION AND HYPOTHESES

The theoretical framework of our research is based on the cognitive social theory (Bandura, 2001, 2006), wherein human functioning is understood through the reciprocal interactions between personal characteristics, environmental contexts, and behaviors. More specifically, it is based on two modern expectancy-value theories such as (a) the expectancy-value theory of Eccles et al. (Wigfield et al., 2009, 2016) for science learning motivation variables (relevance to personal goals and self-efficacy in science learning), and (b) the control-value theory of achievement emotions by Pekrun et al. (2006) and Pekrun and Perry (2014) for (boredom and enjoyment) emotions. These theories link performance, persistence, and individual choices to beliefs related to expectations and values of tasks. The control-value model of Pekrun et al. focuses on achievement control perceptions while the Eccles et al. model focuses on success expectations (Rosenzweig et al., 2019). We would also like to add another perspective from the expectation-value theory regarding identity and its formation (Eccles, 2009), concerning the role of individual and group identities in motivated action through their influence on success expectations and the subjective values of tasks. The identity construct is particularly important in the field of teacher preparation (Avraamidou, 2014), because when making the transition from student to teacher, future teachers must not only acquire a complex set of knowledge, skills, and understanding of pedagogical practices but also create and recreate their image as members of a professional community. It should be noted that there are at least two important aspects, such as identity as a science teacher (Avraamidou, 2014) and science identity (Avraamidou, 2020) during the development of initial identity as an elementary science teacher. Given that science identity is much more related to our work, a model has been developed and results obtained on the importance of recognition on identity (Carlone & Johnson, 2007), and on the fact that Science, Technology, Engineering and Mathematics (STEM) identity mediates the relationship between stereotypes and STEM (Science, Technology, Engineering and Mathematics) motivation (Starr, 2018).

And lastly, on the subject of the theoretical framework for engagement, worth highlighting is the job-demands resources (JD-R) theory (Bakker & Demerouti, 2007; Demerouti et al., 2001), which has had very extensive use in occupational settings including that of teachers, and has also been used with students. Demands include time pressure and occupation, role conflicts, or workload. Resources can be autonomy and organizational support or teacher support for students. High demands increase the risk of burnout and lead to negative results, but resources play a motivating role, stimulate engagement, and foster positive organizational outcomes, such as performance or engagement (Bakker & Demerouti, 2017). The essential assumptions within the JD-R model are that demands predict exhaustion, resources predict engagement, and resources also have an impact on burnout.

2.1 | Motivation in science learning

According to Eccles-Parsons et al. (1983), motivation for continuing achievement tasks is further determined by success expectations and the extent to which tasks are valued. Success expectations, including self-efficacy, are defined as individuals' beliefs about the extent to which they will perform future achievement tasks well. The value of the task refers to the extent to which an individual wants to perform a task. Much of the empirical work done in real-world achievement environments shows that the expectations and values of individuals are positively related.

Motivation to learn science attempts to determine why students struggle, the intensity of their efforts, and their beliefs, feelings, and emotions during the science learning process (Glynn et al., 2009). Five key constructs contribute to the motivation to learn and, consequently, to science achievement: intrinsic motivation, extrinsic motivation, goal orientation, self-determination, self-efficacy, and pleasant emotions. As for the relationships between motivational variables, intrinsic value has been found to be related to scientific achievement because of its impact on self-regulation (Kingir et al., 2013).

A decline in adolescent motivation for science learning has been observed (Vedder-Weiss & Fortus, 2011, 2013, 2018). It has been suggested that this decline is partially due to less relevance attached to mastery goals by science schools and teachers, and also that teaching practices associated with the nature of the task and student's autonomy were strongly related to motivation in adolescents and preventing its decline as students grow older. Academic success is not synonymous with deep engagement in science, and genuine interest is construed as the value students place on their acquired scientific knowledge and skills (Carlone et al., 2014).

Cobern and Loving (2002) state that it is essential to take into account what we expect from elementary science school teachers. If the expectation is limited to just engaging them in scientific activities, then their engagement with science will be minimal. As demands for elementary teachers have increased, a significant, deep, and sophisticated engagement with science is increasingly needed, which authors call critical engagement with science. Developing connections with prior knowledge, especially with knowledge traditionally regarded as external to science, is important for them to have a critical engagement with science.

Preservice elementary teachers are more motivated toward pedagogical preparation than toward science preparation, contrary to what is observed in preservice secondary science teachers (Sorgo et al., 2017). There are also differences in self-efficacy beliefs, and the correlation between motivation toward scientific education, pedagogy, and self-efficacy beliefs is low.

This study analyzed two science learning motivational variables. The first is the relevance of science to personal goals (hereinafter “relevance to personal goals”), and the second is self-efficacy in science learning (hereinafter “self-efficacy”).

2.1.1 | Relevance to personal goals

Students with learning goals tend to be intrinsically motivated and thus seek to understand and master scientific content and skills (Cavallo et al., 2003). The relevance of science learning is defined based on student goals (Cavallo et al., 2003; Glynn et al., 2009). Relevance is linked to students' personal valuation of science derived from their sense of fun and enjoyment when they participate in science-learning activities (Shumow et al., 2013).

The personal value of science is expected to be a powerful predictor of students' science enjoyment (Ainley & Ainley, 2011a, 2011b), and enjoyment is a predictor of students' interest in science learning. Using topics that are relevant to students positively affects their interest and achievement in science (Kang & Keinonen, 2018). It has also been confirmed that personal interest improves students' engagement and performance in Physics, protects them from disengagement (González & Paoloni, 2015), and that belief in the altruistic value of science predicts interest in science (Weisgram & Bigler, 2007).

2.1.2 | Self-efficacy

Bandura (1997) defines it as beliefs in self-abilities to organize and implement the required action to produce certain achievements. Self-efficacy refers to students' confidence that they can achieve good results in science (Glynn et al., 2009).

The construction of efficacy beliefs and learning objectives in preservice primary teachers has been found to have multiple sources (Phelps, 2010), such as past performance, indirect experiences, verbal persuasion, or professional goals. A good sense of effectiveness was found in Australian preservice primary teachers (O'Neill & Stephenson, 2012), with no difference in effectiveness in management, instruction, or classroom participation observed. Furthermore, personal qualities and affective states predicted self-efficacy evaluations. When preservice teachers are very anxious, scared, or stressed, they tend to adopt a more traditional teaching orientation (Cansiz & Cansiz, 2019). Menon and Sadler (2016) observed a positive moderate relationship between gains in science conceptual understandings and gains in personal science teaching efficacy beliefs, as well as positive qualitative changes in their science teacher self-image and confidence to teach science.

Examination of preservice elementary teachers' beliefs about science and science teaching has shown that the descriptors used were overwhelmingly negative (Tosun, 2000). This suggests that negative feelings overshadow the influence of science achievement in self-efficacy in science education. The interrelation between beliefs, self-efficacy, and attitudes in preservice primary science teachers has been highlighted (Kazempour & Sadler, 2015). These three domains do not function on their own, but are interrelated and influence science teaching practices. Preservice primary teachers' self-efficacy beliefs have been shown to be significantly related to their emotions about future teaching (Brígido, Borrachero et al., 2013).

2.2 | Emotions

Academic emotions can be grouped according to approach (Pekrun, 2006) into (a) achievement emotions that relate to the success or failure of an achievement task, (b) thematic emotions that relate to the content of what is being learned, (c) social emotions that are directed toward others, and (d) epistemic emotions which focus on knowledge generating learning aspects that result from the cognitive and epistemic qualities of information and its processing.

Achievement emotions are defined as affective arousal directly related to academic activities (study) or academic results (success and failure) (Pekrun & Perry, 2014). Emotions exert an important influence on students' learning, performance, health, and well-being (Pekrun, 2006). The basic proposals in the control-value theory of achievement emotions (Pekrun, 2006; Pekrun & Perry, 2014) refer to the antecedents of emotions, where control and value estimates are considered as the proximal antecedents of academic achievement emotions. The theory also acknowledges that achievement activities and their outcomes influence achievement emotions and their antecedents, which implies that achievement emotions, their origins, and outcomes are linked by a causal reciprocity as indicated by the derivative model of this theory focused on teacher–student relations (Frenzel, 2014). The control-value theory (Pekrun, 2006; Pekrun & Perry, 2014) establishes that achievement emotions influence learning and performance through diverse cognitive and motivational mechanisms, and similarly in different individuals, genders, subjects, and sociohistorical contexts.

In the three-dimensional taxonomy of academic achievement emotions, which is part of the control-value theory (Pekrun, 2006), these are first distinguished by object versus those of outcome. Moreover, achievement emotions can be grouped according to their *valence* and implicit degree of *activation*. In terms of valence, positive (i.e., pleasant) emotions such as enjoyment can be distinguished from negative ones (i.e., unpleasant) such as boredom. In terms of activation, the physiologically activating emotions such as enjoyment can be distinguished from deactivating ones such as boredom. By using the valence and activation dimensions, the taxonomy is consistent with the circumplex models that organize emotive states in a two-dimensional space (valence × activation; Feldman-Barrett & Russell, 1998).

Research into emotions in education has been on the rise since the 1990s (Pekrun & Linnenbrink-Garcia, 2014), and a similar trend is observed in research into emotions in the science teaching field, where worth highlighting is the overall importance of the qualitative approach associated with the sociology of emotions (e.g., from recent works Davidson et al., 2020; Davis & Bellocchi, 2020; Davis et al., 2020), and in particular the research into initial preparation of science teachers conducted in the Spanish-speaking educational field (e.g., Borrachero et al., 2014; Jeong et al., 2016, 2019; Brígido, Borrachero et al., 2013; Brígido, Couso et al., 2013).

Research into non-science teaching teachers showed that they expected more pleasure than anger and anxiety from future teaching (Eren, 2014). Furthermore, type of attention and social intuition play a mediating role between emotions (enjoyment and anger) and professional teaching plans. By studying the role of teacher's emotions in science teaching and student learning, Zembylas (2004) demonstrates how emotional performance at work is an important aspect of reality in science education. In her study, the teacher was ready to do emotional work involving some suffering as long as it was emotionally rewarding.

In a study on the emotions of preservice high school science teachers when teaching (Hugo et al., 2013), four styles of emotional work were observed (sensitive, seductive, overwhelmed, and phlegmatic), which are characterized by variables associated with the change or permanence of the initial education model. In preservice primary teachers, Brígido, Borrachero et al. (2013) showed that positive emotions predominate in the learning of Biology and Geology, while negative ones predominate in learning Physics and Chemistry. Furthermore, the emotions teachers had felt as students when they were learning those subjects in high school correlated with the emotions they now felt about future teaching.

In this study, two emotional variables of science learning were analyzed. The first was boredom in science class (henceforth, “boredom”), and the second was enjoyment in science class (henceforth, “enjoyment”).

2.2.1 | Boredom

Boredom is a relatively prevalent emotion in science learning and has been documented among college students learning science and technology (Graesser & Mello, 2012). Thus, most Australian students, at the end of secondary education, show little interest in science because they consider it boring, and have no intention of continuing with science-related studies or work (Newhouse, 2017).

Students are less bored when they are motivated, perceive high levels of control, have effective teachers, and learning tasks are not monotonous (Pekrun, 2006). Perceptions of the content value, tasks, situations, learning outcomes, and performance show clear negative correlations with boredom (Goetz et al., 2006; Pekrun et al., 2011).

Eren (2016) observed that the relationships between boredom and engagement were mediated by cognitive strategies in preservice teachers. The negative effects of boredom can be clearly reduced with the adoption of cognitive strategies and emotional engagement.

2.2.2 | Enjoyment

Science enjoyment is defined as the degree to which science classes are generally enjoyed (Wang & Berlin, 2010). A positive relationship has been observed in several countries between enjoyment and scientific achievement (Areepattamannil et al., 2011; Jen et al., 2013; Lam & Lau, 2014; Lavonen & Laaksonen, 2009; Ng et al., 2012; Tighezza, 2014; Tsai & Yang, 2015), even though enjoyment has also been negatively related to science achievement in Middle Eastern and North African countries (Bouhlila, 2011).

In an extensive international survey of science achievement, Ainley and Ainley (2011a) verified the importance of enjoyment in science engagement. Moreover, a growing interest without enjoyment may not lead to a genuine interest in science learning, where genuine interest is the value students give to their acquired scientific knowledge and skills (Jack & Lin, 2018).

Bulunuz and Jarrett (2010) observed that science enjoyment ratings were somewhat lower in college education than in middle and secondary education. This implies the need for examining and possibly reviewing the scientific content of the subjects in the initial university preparation of elementary teachers.

Brígido, Borrachero et al. (2013) observed positive emotions toward Biology and Geology and negative emotions toward Physics and Chemistry in the initial preparation of primary school teachers. Concerning the emotions experienced as high school students, the positive emotions expected in future science education increased, and the negative ones decreased (Brígido, Couso et al., 2013).

2.3 | Engagement

Engagement is defined as a positive and satisfactory mental state distinguished by vigor, dedication, and absorption (Schaufeli, Martinez et al., 2002; Schaufeli, Salanova et al., 2002). Engagement is a persistent and pervasive affective-cognitive state that does not focus on specific objects, events, individuals, or behaviors.

A study carried out on a very large international sample using a structural equation model (SEM; Ainley & Ainley, 2011a) showed that interest in science and the value and knowledge of science influence the current and future participation in science learning, and that enjoyment is a key mediator in this process. The relationships between interest and enjoyment with future engagement are much stronger than their relationship with self-efficacy and self-concept (Lin et al., 2013). Therefore, it appears that scientific competence alone does not guarantee future engagement in science.

Future science orientation, motivation, and enjoyment are associated with the diversity and frequency of classroom activities (Hampden-Thompson & Bennett, 2013). The type of activities also influences engagement in science (Grabau & Ma, 2017); thus, some activities (models, applied activities) are associated with science enjoyment and the personal value of science, whereas others (practical activities) are associated with self-efficacy and general interest in science learning.

In another line, Volet et al. (2019), in preservice primary teachers performing collaborative science activities, observed differences in the quality of individual and group engagement related to attitude, group, and activity.

In this study, the variables of engagement in science studies (hereinafter "engagement") were analyzed.

2.4 | Relationship between variables and research hypotheses

Based on previous research, the relationships between three groups of variables are analyzed in a sample of preservice elementary teachers (Figure 1): motivation to learn science (relevance to personal goals and self-efficacy), emotions in science class (boredom and enjoyment), and engagement in science studies (vigor, dedication, absorption). The first objective is to analyze the relationships between variables from the different groups, the primary hypotheses. The second objective is to analyze the relationships between variables within each group, the secondary hypotheses.

The expectancy-value theory (Eccles, 2009; Eccles & Wigfield, 2002) and the control-value theory (Pekrun, 2006) support the relationships between self-concept and emotions. According to the two theories, perceptions of expectations and values or estimates of control and value influence the choice of tasks, emotions, and behavior.

2.4.1 | Predictors of emotions and engagement

Hypothesis H1. *Relevance to personal goals will negatively predict boredom (H1a) and positively predict engagement (H1b) and enjoyment (H1c). As a secondary hypothesis, relevance to personal goals will positively predict self-efficacy (H1d).*

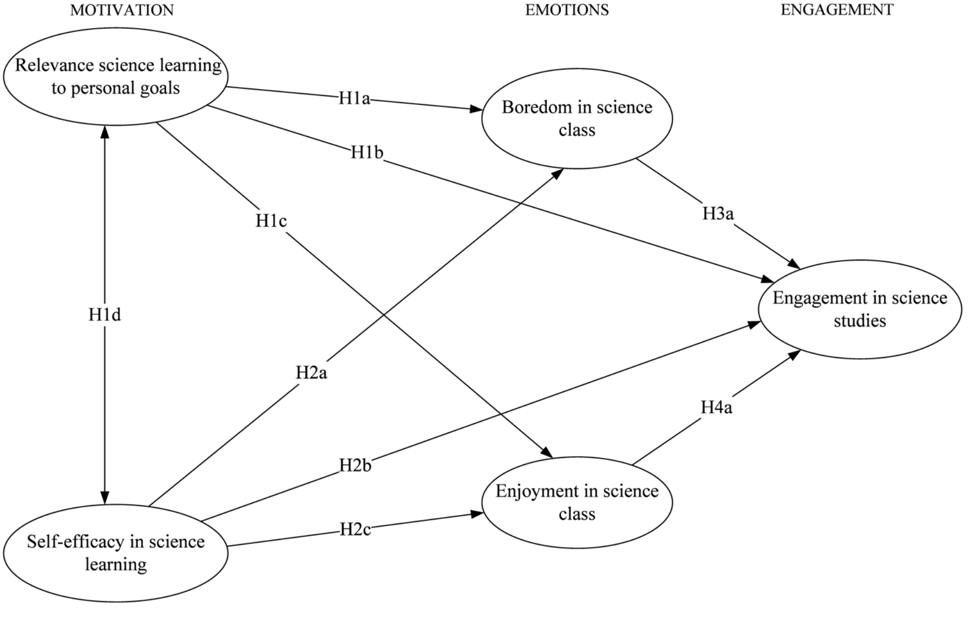

FIGURE 1 Proposed model of the hypothesis

Hypothesis H2. *Self-efficacy will negatively predict boredom (H2a) and positively predict engagement (H2b) and enjoyment (H2c).*

2.4.2 | Emotions as predictors of engagement

Hypothesis H3. *Boredom will negatively predict engagement (H3a).*

Hypothesis H4. *Enjoyment will positively predict engagement (H4a).*

2.4.3 | Emotions as mediators of engagement

Hypothesis H5a. *Boredom will mediate between relevance to personal goals and engagement.*

Hypothesis H5b. *Boredom will mediate between self-efficacy and engagement.*

Hypothesis H6a. *Enjoyment will mediate between relevance to personal goals and engagement.*

Hypothesis H6b. *Enjoyment will mediate between self-efficacy and engagement.*

2.5 | Research interest

This study expands our knowledge of motivation, emotions, and engagement of preservice elementary teachers in science learning because:

(a) In terms of motivation, two important motivational variables (relevance to personal goals and self-efficacy) are analyzed together, something that, as far as we know, had not been done before.

Relevance to personal goals was studied because of the importance of personal and situational interest in learning science. In this regard, Ainley and Ainley (2011a) reported the influence of interest and the value of science on students' enjoyment and, ultimately, in their current and future engagement in science.

Self-efficacy has been a focus of research due to its key role as a predictor of emotions and performance (Britner, 2008; Pekrun & Perry, 2014; Sawtelle et al., 2012), engagement (Hampden-Thompson & Bennett, 2013), and the numerous results that relate self-efficacy to science achievements (see the review of Perera, 2014).

(b) In terms of emotions, boredom and enjoyment are measured because they are two of the most frequent emotions of students in the academic context (Pekrun & Perry, 2014), and because of the recommendation to analyze positive emotions and not just negative ones in science education research (Sinatra et al., 2014).

(c) In relation to engagement, previous research on the relationship between motivation, emotions, and engagement has been very scarce.

The most complex relationships found in the scientific literature in secondary students' science learning (Grabau & Ma, 2017) revealed that applied activities or models were positively related to enjoyment and the personal value of science, whereas practical activities were positively related to science self-efficacy and general interest in science learning.

(d) The relationship between a set of important motivational, emotional, and engagement variables was calculated using SEM. We are unaware of any similar studies in preservice elementary teachers that undertook a comprehensive analysis of the influence of a similar set of motivational and emotional antecedents on a key science learning dimension, such as engagement.

This is a cross-sectional, quantitative, and correlational research in which a set of variables are analyzed simultaneously using SEM, a methodology that has advantages over correlation and regression analysis. In educational research, it is interesting to study theoretical constructs (latent variables) that cannot be measured directly (Byrne, 2010). Therefore, latent variables must be linked to an observable variable that can be measured. The SEM methodology allows the joint investigation of complex relationships between various latent and observed variables.

An additional reason to evaluate this set of motivational, emotional, and engagement variables was that, to some extent, they are all not only influenced by future teachers, but also by the educators and educational institutions responsible for initial teacher preparation. Second, relevance to personal goals and self-efficacy must be promoted. Third, science learning-related emotions can be improved during elementary teachers' initial preparation by changing instructional strategies.

3 | METHODS

3.1 | Context

The Spanish education system consists of three basic levels of nonuniversity education: early childhood education (0–6 years), primary education (6–12 years), and secondary education (12–18 years). Early childhood education has a first stage (0–3-year old) and a second stage (3–6-year old) (Ministry of Education, 2007a). Specialized teachers are engaged in teaching at each of the three nonuniversity educational levels. Ever since the introduction of the European Higher Education Area, both early childhood and primary teachers are required to obtain a 4-year university degree in education and/or teacher preparation faculties. The curricula are quite similar in all Spanish universities because preparation in these professions is regulated by the State educational authorities (Ministry of Education, 2007a, 2007b). Therefore, the curricula for early childhood and primary teacher preparation in the three universities involved in this study are similar. Science preparation and instruction received by preservice elementary teachers is also similar. Thus, early childhood teacher preparation only has one compulsory science teaching subject out of a total of between 27 and 28 compulsory subjects in the three curricula, and class duration is approximately 60 h. There are 2–2.5 compulsory science teaching subjects in primary teacher preparation, and one university also offers a science preparation subject, all with a duration of approximately 60 h.

A recent work (Verdugo-Perona et al., 2019) evaluated the conceptual and procedural knowledge before and after studying science subjects during initial preparation in primary education in a Spanish region. Results show significant but few improvements in the levels of conceptual and procedural knowledge throughout the degree program, indicating that the educational needs for science preparation were not adequately met.

3.2 | Participants

The sample consisted of 871 students enrolled in subjects related to science and its teaching at three Spanish universities in six preparation centers (1 = 189, 2 = 144, 3 = 106, 4 = 140, 5 = 112, 6 = 180); four academic years (1st = 7, 2nd = 383, 3rd = 167, 4th = 197); three age groups (17–21 years = 492, 22–30 years = 343, >30 years = 31); with predominance of women ($n = 686$) over men ($n = 178$); and with four groups according to previous teaching experience (none = 147, private or similar classes = 435, nonregulated or similar teaching = 228, regulated teaching = 43).

3.3 | Instruments

The questionnaire includes sociodemographic variables: school (1, 2, 3, 4, 5, 6), academic year (1st, 2nd, 3rd, 4th), gender (female = 1/male = 2), age (1 = 17–21; 2 = 22–30; 3 = +30 years), previous teaching experience (0 = none; 1 = private or similar classes, 2 = nonregulated or similar teaching; 3 = regulated teaching).

The following are the items for the target variables or dimensions:

Relevance to personal goals and self-efficacy. These were measured using the Science Motivation Questionnaire (Glynn et al., 2009).

This Likert-type instrument is designed to provide science education researchers and science instructors information on student motivation toward learning science. An exploratory factorial analysis provided evidence of construct validity (Glynn et al., 2007), thereby indicating that it is a reliable instrument (Glynn & Koballa, 2006; Glynn et al., 2007, 2009). The instrument's general reliability and validity related to criterion has been confirmed with new evidence of its construct validity (Glynn et al., 2009) and other researchers state that it is a good specific measure of motivation toward science learning (Glynn & Koballa, 2006, Glynn et al., 2007, 2009).

Each scale contained three items rated on a 5-point Likert scale ranging from 1 (*never*) to 5 (*always*), that were selected from those with the greatest weight in each of the dimensions. Relevance to personal goals. Items: "The science I learn relates to my personal goals," "The science I learn is relevant to my life," "The science I learn has practical value for me." Self-efficacy. Items: "I expect to do as well as or better than other students in the science course," "I am confident I will do well in the science tests," "I believe I can get an 'A' grade in the science course."

Boredom and enjoyment. These were measured with the Achievement Emotions Questionnaire for Pre-Adolescents (AEQ-PA; Peixoto et al., 2015), adapted from the AEQ (Pekrun et al., 2005). The AEQ-PA adequately evaluates achievement emotions, including boredom and enjoyment related to classroom attendance. The confirmatory factor analyses (CFA) and descriptive statistics support the reliability and internal validity of the instrument. Moreover, the pattern of relationships between emotions is similar to the findings of Pekrun et al. (2011), with the observation of positive relationships between emotions of the same valence and negative relationships between emotions of different valences. Recently Perkins et al. (2020), using a sample of 955 college students, reported that four emotions (anger, boredom, enjoyment, and pride) were different and showed metric and scale configuration invariance in the test.

The wording was adapted (AEQ-PA; Peixoto et al., 2015) by replacing the term "mathematics" with the term "science" in the original questionnaire so that it could be used with generalist preservice elementary science teachers.

Each scale contained three items rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), that were selected from those with the greatest weight in each of the dimensions. Boredom items: "I get bored during science classes," "Science classes bore me," "I find my science classes fairly dull." Enjoyment: "I enjoy being in my science class," "I feel excited about being in my science class listening to the teacher," "I'm glad that it paid off to go to my science class."

Engagement. The Utrecht Work Engagement Student Scale (UWES) was used with three subscales of three items (UWES-9; Schaufeli et al., 2006): vigor, dedication, and absorption, generated from a larger version of 17 items (Schaufeli, Salanova et al., 2002). Schaufeli et al. (2006) collected data from 10 different countries (N = 14.521) and stated that the factorial validity of the UWES-9 was demonstrated by confirmatory factorial analysis, and the scores for the three scales have good internal consistency and test–retest reliability. They conclude that UWES-9 has acceptable psychometric properties and that the instrument can be used in studies of positive organizational behavior.

UWES-S measurement invariance was determined in high school and university student samples by Cadime et al. (2016) who observed that the three-factor structure (vigor, absorption, and engagement) is better adjusted and being invariant allows comparisons between the two levels. The UWES-S has been validated in several languages and countries, such as Spain (Serrano et al., 2019) and Chile (Carmona-Halty et al., 2019).

The wording of the UWES-S was adapted by adding the term "science" to the terms "studies" or "study" in the original questionnaire items so that it could be applied to generalist preservice science elementary teachers.

Each scale contained three items on a 7-point Likert scale with values from 0 (*never*) to 6 (*every day*). In our case, all items in the Brief Student Utrecht Work Engagement Scale (UWES-S-9) were chosen: Vigor Items: "At my science studies, I feel bursting with energy," "At my science studies, I feel strong and vigorous," "When I get up in the morning, I feel like going to my science studies." Dedication Items: "I am enthusiastic about my science studies," "My science studies inspire me," "I am proud of my science studies." Absorption Items: "I feel happy when I study science intensely," "I am immersed in my science studies," "I get carried away when I study science."

3.4 | Procedure

Six existing preservice elementary teacher preparation centers from a Spanish region were selected for the study. Participation of students enrolled in science-related subjects was requested, and informed consent was obtained from those who participated voluntarily and anonymously.

3.5 | Data analysis design

SPSS 24 was used for preliminary data analysis and AMOS 24 was used for the three-step analysis. The suitability of each scale was first assessed using several CFA. The Cronbach's α, composite reliability coefficient (CR), and average variance extracted (AVE) were calculated as reliability indices (Hair et al., 2010). The Pearson's bivariate correlations between variables were also calculated. A SEM was then implemented to test the proposed model of relationships between variables in two steps (Figure 1) to estimate the measurement model and the structural model (Byrne, 2010). Lastly, the mediated relationships between variables were analyzed using the bootstrap method (Preacher & Hayes, 2008).

4 | RESULTS

4.1 | Preliminary analysis

The adequacy of each scale was first verified by CFA, obtaining adequate values for various reliability indices. Descriptive statistics and correlations between variables were also calculated (Table 1).

The fit of the model to the results of the determinants associated with science learning was confirmed by CFA for motivation (relevance to personal goals, self-efficacy, $\chi^2/df.$ = 5,125, goodness-of-fit index [GFI] = 0.985, comparative fit index [CFI] = 0.984, root mean square error of approximation [RMSEA] = 0.069), emotions (boredom and enjoyment, χ^2/df = 0.906, GFI = 0.906, CFI = 0.997, RMSEA = 0.000), and engagement (vigor, dedication, absorption, χ^2/df = 16,859, GFI = 0.953, RMSEA = 0.135). All variables showed adequate reliability indices (α, CR, and AVE; see Table 1), and skewness and kurtosis indices that confirmed the assumption of univariate normality.

TABLE 1 Correlations bivariate, reliability indices, and other descriptive statistics

	1	2	3	4	5
1. Relevance to personal goals					
2. Self-efficacy	0.400		–		
3. Boredom	−0.416	−0.251			
4. Enjoyment	0.533	0.411	−0.612		
5. Engagement	0.574	0.452	−0.523	0.697	
Mean	3.39	3.52	2.44	3.44	3.29
SD	0.82	0.77	0.90	0.77	1.50
Skewness	−0.32	−0.43	0.35	−0.48	−0.28
Kurtosis	0.16	0.14	−0.08	0.47	−0.81
Cronbach's α	0.859	0.747	0.713	0.872	0.759
CR	0.64	0.56	0.70	0.51	0.87
AVE	0.84	0.78	0.87	0.76	0.95

Note: $r < 0.071$ nonsignificant; $r \geq 0.071$, $^*p < 0.05$; $r > 0.087$, $^{**}p < 0.01$.
Abbreviations: AVE, average variance extracted; CR, composite reliability.

All measured variables were significantly correlated, with values of $r = -0.612$ to $r = 0.697$. Some were stronger, such as between engagement and enjoyment ($r = 0.697$) and between enjoyment and boredom ($r = -0.612$), followed by correlations of engagement and relevance to personal goals ($r = 0.574$), enjoyment and relevance to personal goals ($r = 0.533$), engagement and boredom ($r = -0.523$), and engagement and self-efficacy ($r = 0.452$).

4.2 | Measurement model

Three scores were used as indicators for each latent variable. Therefore, the CFA was performed with 15 indicators for five latent variables (see Figure 2). The measurement model fits the data well ($\chi^2/df = 2{,}164$, GFI = 0.974, CFI = 0.989, RMSEA = 0.037). The standardized factorial loads (standardized regression weights), which represent the relationships between latent variables and indicators, varied from SE12 = 0.416 to SE29 = 0.892, all statistically significant ($p < 0.001$). All correlations between latent variables were likewise significant ($p < 0.001$).

4.3 | Structural equation model

A SEM was then performed to test the hypotheses concerning the relationships between the variables (Figure 3). The model fits the data well, as revealed by the indices: χ^2/df ($\chi^2 = 401{,}382$, $df = 81$) = 4.955, GFI = 0.943, CFI = 0.962, RMSEA = 0.067 (Figure 3).

Relevance to personal goals negatively predicted boredom ($\beta = -0.47$, $p < 0.001$) and positively predicted enjoyment ($\beta = 0.56$, $p < 0.001$) and engagement ($\beta = 0.14$, $p = 0.001$). Self-efficacy negatively predicted boredom ($\beta = -0.10$, $p < 0.001$) and positively predicted enjoyment ($\beta = 0.28$, $p < 0.001$) and engagement ($\beta = 0.08$, $p = 0.01$). Boredom negatively predicted engagement ($\beta = -0.11$, $p < 0.001$), and enjoyment positively predicted engagement ($\beta = 0.61$, $p < 0.001$). The explained variance was 27% for boredom, 52% for enjoyment, and 67% for engagement.

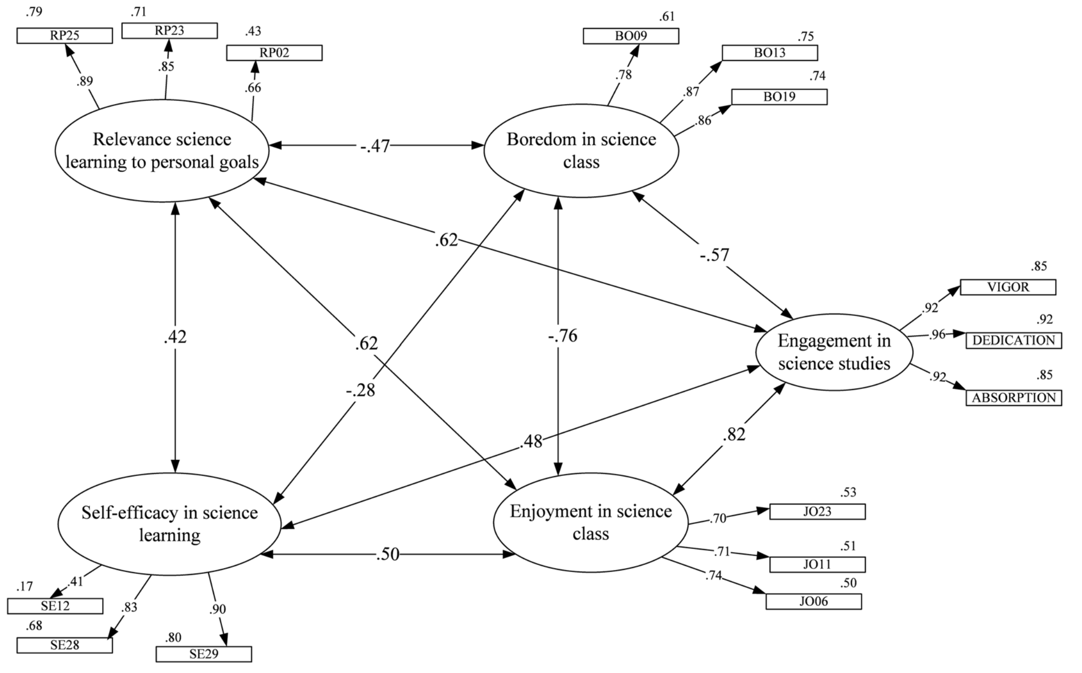

FIGURE 2 Measurement model (standardized factor loadings between indicators and latent variables). BO, boredom items; JO, enjoyment items; RP, relevance to personal goals items; SE, self-efficacy items

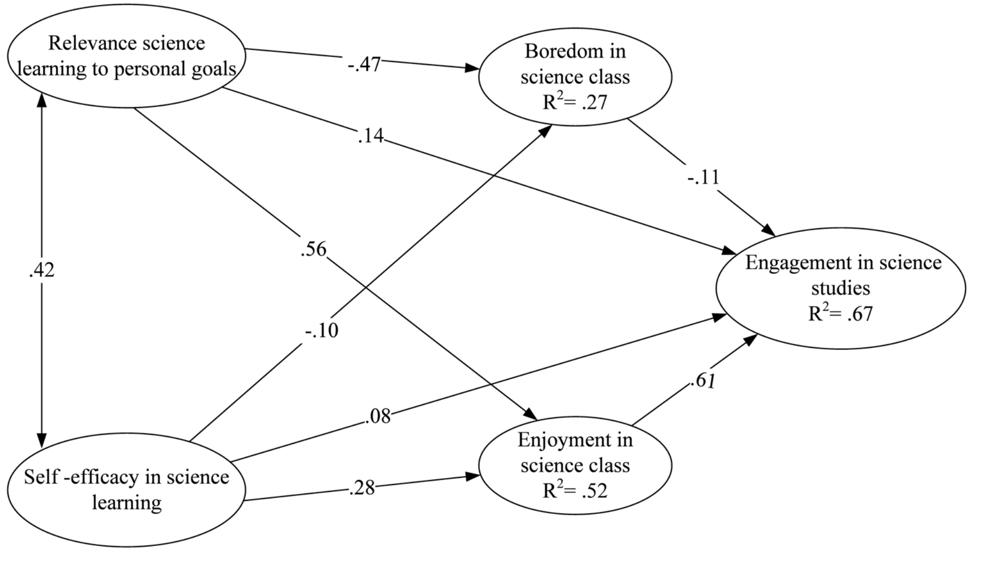

FIGURE 3 Standardized parameter values of the final structural model

TABLE 2 Direct, indirect, and total effects of the relevance to personal goals and self-efficacy on engagement

Predictor → criterion	Direct effect (*p*)	Indirect effect		Total effect (*p*)
		Sum (*p*)[a]	CI	
Partial mediation				
Relevance to personal goals → engagement	0.144 (0.004)	0.394 (<0.001)	0.314, 0.490	0.538 (<0.001)
Self-efficacy → engagement	0.084 (0.018)	0.180 (<0.001)	0.110, 0.258	0.263 (<0.001)

Abbreviation: CI, confidence interval.

[a]Using the AMOS 24 (CI = 95%; samples = 5000).

4.4 | Mediated relationships

Finally, we examined a possible mediation between variables, and whether it was partial or total. The AMOS 24 software estimates indirect mediation, whose importance and significance is obtained from the initial confidence interval (Preacher & Hayes, 2008; Table 2).

Relevance to personal goals positively predicted engagement directly ($\beta = 0.144$, $p = 0.004$) and indirectly ($\beta = 0.394$, $p \le 0.001$), and improved engagement.

Self-efficacy positively predicted engagement directly ($\beta = 0.084$, $p = 0.018$) and indirectly ($\beta = 0.180$, $p \le 0.001$), and improved engagement. Therefore, in both cases, there was partial mediation between relevance to personal goals and self-efficacy with engagement.

5 | DISCUSSION

The relationships between the three sets of variables associated with science learning were analyzed—motivational variable antecedents (relevance to personal goals and self-efficacy), emotional variables (boredom and enjoyment), and engagement variables (vigor, dedication, absorption). A preliminary analysis determined the adequacy of the instruments applied. The proposed scale structure fits the data well, as shown by CFAs, with adequate reliability indices.

This study makes important contributions from several viewpoints: theoretical, empirical, and practical.

5.1 | Theoretical implications

The research is situated within the framework of the social cognitive theory developed by Bandura, (1986, 2001, 2006). In this sense, the results on the close relationship between the motivation to learn science (relevance to personal goals and self-efficacy) and engagement in science learning in preservice elementary teachers needs to be interpreted.

Furthermore, according to the expectancy-value (Eccles, 2009; Eccles & Wigfield, 2002) and control-value theories (Pekrun, 2006; Pekrun & Perry, 2014), perceptions of expectations and values or estimates of control and value influence the choice of tasks, emotions, and behavior. In this sense, the results reveal the important mediating role of emotions (boredom and enjoyment) between motivation (relevance to personal goals and self-efficacy) and engagement in science learning. Emotions are considered as mediators of the science learning experience, through cognition, motivation, engagement, and learning outcomes (Sinatra et al., 2014).

5.2 | Empirical contributions

We understand that this is the first study that uses a two-step SEM analysis to connect variables such as relevance to personal goals and self-efficacy, with achievement emotions such as boredom and enjoyment, and all of these variables with preservice elementary teachers' engagement.

5.2.1 | Confirmation of previous research

As hypothesized, when adding direct and indirect effects, preservice elementary teachers with a better attitude to science learning (more relevance to personal goals and self-efficacy) had more positive emotions (less boredom and more enjoyment) and experienced more engagement (more vigor, dedication, and absorption).

As expected, the personal value of science is a strong predictor of science enjoyment (Ainley & Ainley, 2011a, 2011b). Moreover, high self-efficacy in science learning is associated with greater engagement (Uçar & Sungur, 2017).

5.2.2 | New contributions

Although there are contributions in this line in other educational levels such as secondary education (Ainley & Ainley, 2011a; Grabau & Ma, 2017), very little research has been done on the relationships between motivational variables, emotions, and engagement, in preservice elementary teachers. In this sense, SEM allows the design of theory-based models with a certain number of variables, and, at the same time, it measures all relationships between these variables, in particular, the mediated relationships that cannot be observed with traditional methodologies.

Hence, one of the main contributions refers to the mediating role of emotions, enjoyment and boredom (Table 3).

Preservice elementary teachers showed higher engagement when they experienced few negative emotions such as boredom (H5) and more positive emotions such as enjoyment (H6), and were moreover more satisfied with the relevance to personal goals and their self-efficacy.

In accordance with the first research objective, preservice elementary teachers who perceived more relevance to personal goals and greater self-efficacy, and who therefore experienced less negative emotions such as boredom, and more intense positive emotions, such as enjoyment, engaged more autonomously in their preservice science preparation studies as elementary teachers.

Learners are less bored when they have high levels of motivation, effective teachers, and nonmonotonous learning tasks (Pekrun, 2006).

TABLE 3 Results of mediation

Label	Predictor	Mediator(s)	Criterion	Sig.
H5a	Relevance to personal goals	Boredom	Engagement	Yes
H5b	Self-efficacy	Boredom	Engagement	Yes
H6a	Relevance to personal goals	Enjoyment	Engagement	Yes
H6b	Self-efficacy	Enjoyment	Engagement	Yes

The results are expected to apply to other preservice teachers. The relevance to personal goals and self-efficacy and related emotions such as boredom and enjoyment can influence their engagement.

5.3 | Practical implications

And lastly, it is possible to improve self-efficacy and influence relevance to personal goals, by increasing enjoyment and reducing boredom, and thus promote preservice elementary teachers' engagement in science learning.

Effective preparation programs should promote motivation, emotion, and engagement in science among preservice elementary teachers. In this regard, they should stimulate the improvement of beliefs, attitudes, and self-efficacy in preservice elementary science teachers concerning effective teaching methods and basic issues of science education (Kazempour & Sadler, 2015). There are different pathways associated with initial preparation, such as:

5.3.1 | Promoting engagement by improving motivation for science

One of the ways would be to promote interest in science. The use of relevant topics, and research-based or discussion-based learning develop general interest (Kang & Keinonen, 2018). Long-term interest in science can be promoted through repeated short-term situational interest experiences (Baptiste et al., 2019), through hands-on activities, relevant science learning, student-centered strategies, or by making classes entertaining. Situational interest is generated through various teaching techniques when they combine success, relevance, and novelty (Palmer et al., 2016).

Another way would be through certain curricular orientations such as inquiry-based science education. In this sense, it has been pointed out that classroom activities oriented to inquiry-based science education should be an important component of preservice preparation in science education (Morrell & Carroll, 2003). However, inquiry-based pedagogy is still absent or not implemented in teacher preparation (Haefner & Zembal-Saul, 2004). In a case of implementation of inquiry-based science education for primary preservice teachers (Avery & Meyer, 2012), improvements were observed in science comprehension, scientific process, and scientific inquiry, as well as in confidence in science and science teaching. Inquiry-based teaching benefits, which improved confidence, enjoyment, anxiety, and the relevance of science (Riegle-Crumb et al., 2015) have been observed in preservice teachers. It has been recommended that preservice elementary teachers be involved in coherent, research-based scientific investigations in a single domain, and subsequently be provided planning and teaching opportunities with elementary school children (Plummer & Ozcelik, 2015). Moreover, less well-founded curricular orientations are possible, such as hands-on-science activities, which can promote motivation in science, and these in turn, motivate preservice preschool teachers to use them in their own classrooms after rating them as entertaining, interesting, and with a high level of learning in their preparation (Bulunuz, 2012). Another option could be the so-called “scientific activities that work” by experienced primary school teachers (Appleton, 2002). Activities that work are practical, interesting, and motivating, have a clear result, are manageable in the classroom, need readily available equipment, and are preferably used in a context where science is integrated with other subjects.

Other methodologies can promote motivation in science learning in preservice elementary teachers, such as the use of concept maps (Schaal, 2010); the flipped classroom methodology (Jeong et al., 2016), cooperative learning (Fernández-Río et al., 2014), or use of immersive technologies and authentically model scientific inquiry (Reilly et al., 2021).

5.3.2 | Promote engagement by improving emotions in science, increasing enjoyment, and reducing boredom

According to Zembylas (2004), the role of emotions in creation of emotional cultures that inspire science teaching and learning must be taken into account in science education. The author also highlights the importance of recognizing teachers and students as agents in the construction of science teaching and learning of emotional cultures; as well as educators and administrators to assess the possibilities of emotional work in science education. In this sense, the emotion of wonder could play a role by engaging preservice elementary teachers in science, beyond experiences (Gilbert & Byers, 2017).

Eren (2014) mentioned that prospective teachers of various subjects hope to experience more pleasure in future teaching rather than anger and anxiety, and indicated the emotions and emotional styles that should be taken into account to understand future teaching plans. The value of analyzing all the positive and negative emotional expressions of preservice primary teachers in science learning environments has also been pointed out by Hufnagel (2015).

Critical emotional reflexivity can become a pedagogical tool in teacher preparation (Zembylas, 2013) to resolve emotional problems, if teachers assess their current status and critically review their professional development.

Davidson et al. (2020) also state that teachers must have opportunities to find, understand, and appreciate the epistemic affection understood as affection within science to help students navigate affection for science.

To learn science, Crawford (2014) recommends interesting possibilities from inquiry to scientific practice such as project-based science, problem-based science, authentic science, citizen science, and model-based inquiry. They also seem like good options to address the lesser known but not the least important concern about preservice teacher engagement in science and its teaching, particularly for generalist preservice teachers who teach science in early childhood and primary education.

5.4 | Limitations and future research

The first limitation of the work is that preservice elementary teacher preparation is probably of a different nature in Spanish universities than in other countries. Second, the data were collected through self-report surveys. Other instruments such as observation or assessment of the classroom environment, emotions, or engagement of preservice elementary teachers in science studies by the educators could be used for data collection. Third, when using a cross-sectional design such as the one applied in this study, there may be reciprocal relationships between variables, as has been proposed in the reciprocal causality models of emotions (Frenzel et al., 2009). Fourth, future research should assess other variables and emotions in the learning environment and use other instruments to assess engagement. Fifth, since only quantitative data were analyzed in this study, it should be supplemented in the future with qualitative or mixed-design research (Creswell & Creswell, 2018; Creswell & Plano-Clark, 2017). The mixed design could better help understand the conformation of the identities of elementary school teachers, both scientific identities (see Reilly et al., 2021, White et al., 2019) and teacher identities (see Mahmoudi-Gahrouei et al., 2016). In this sense, of special research interest is the critical teacher preparation stage, that goes from preservice preparation via practicum up to novice teachers. Finally, factors that influence preservice elementary teachers in other countries or at levels not studied herein, such as preservice secondary teacher preparation, could be investigated in the future.

6 | CONCLUSION

The hypothesis that postulates the importance of the variables associated with motivation, such as relevance to personal goals and self-efficacy, as predictors of emotions (boredom and enjoyment), which in turn, predict engagement, is now confirmed. In this sense, worth highlighting is the relationships between motivation, emotions, and science learning engagement in preservice elementary teachers.

Furthermore, and to the best of our knowledge, this is the first research using a two-step SEM analysis that connects variables such as relevance to personal goals and self-efficacy with achievement emotions such as boredom and enjoyment in class, and all of them with preservice elementary teachers' engagement in science learning.

Finally, and from an applied perspective, one can possibly influence the relevance of teachers' personal goals and self-efficacy by improving emotions and engagement. Interest in science can be increased by implementing student-centered approaches, such as the use of relevant topics or curricular orientations such as inquiry-based learning (Kang & Keinonen, 2018).

ACKNOWLEDGMENT

Funding for open access charge: Universidade de Vigo/CISUG.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Pedro Membiela http://orcid.org/0000-0002-8584-0417
Antonio González http://orcid.org/0000-0003-0038-4801

REFERENCES

Ainley, M., & Ainley, J. (2011a). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology*, *36*(1), 4–12. https://doi.org/10.1016/j.cedpsych.2010.08.001

Ainley, M., & Ainley, J. (2011b). A cultural perspective on the structure of student interest in science. *International Journal of Science Education*, *33*(1), 51–71. https://doi.org/10.1080/09500693.2010.518640

Appleton, K. (2002). Science activities that work: Perceptions of primary school teachers. *Research in Science Education*, *32*(3), 393–410. https://doi.org/10.1023/a:1020878121184

Appleton, K., & Kindt, I. (2002). Beginning elementary teachers' development as teachers of science. *Journal of Science Teacher Education*, *13*(1), 43–61. https://doi.org/10.1023/A:1015181809961

Areepattamannil, S., Freeman, J. G., & Klinger, D. A. (2011). Influences of motivation, self-beliefs, and instructional practices on science achievement of adolescents in Canada. *Social Psychology of Education*, *14*(2), 233–259. https://doi.org/10.1007/s11218-010-9144-9

Avery, L. M., & Meyer, D. Z. (2012). Teaching science as science is practiced: Opportunities and limits for enhancing preservice elementary teachers' self-efficacy for science and science teaching. *School Science and Mathematics*, *112*(7), 395–409. https://doi.org/10.1111/j.1949-8594.2012.00159.x

Avraamidou, L. (2014). Studying science teacher identity: Current insights and future research directions. *Studies in Science Education*, *50*(2), 145–179. https://doi.org/10.1080/03057267.2014.937171

Avraamidou, L. (2020). Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectionality lens. *Cultural Studies of Science Education*, *15*, 323–345. https://doi.org/10.1007/s11422-019-09954-7

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of Managerial Psychology*, *22*(3), 309–328. https://doi.org/10.1108/02683940710733115

Bakker, A. B., & Demerouti, E. (2017). Job demands-resources theory: Taking stock and looking forward. *Journal of Occupational Health Psychology*, *22*(3), 273–285. https://doi.org/10.1037/ocp0000056

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

Bandura, A. (2001). Social cognitive theory: An agentive perspective. *Annual Review of Psychology*, *52*(1), 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Bandura, A. (2006). Going global with social cognitive theory: From prospect to paydirt. In S. I. Donaldson, D. E. Berger, & K. Pezdek (Eds.), *The rise of applied psychology: New frontiers and rewarding careers* (pp. 53–70). Erlbaum.

Baptiste, D. J., Archer, J., & Palmer, D. (2019). Preservice teachers' ideas about how to enhance pupils' long-term interest in science. *Research in Science & Technological Education*, *37*(3), 279–296. https://doi.org/10.1080/02635143.2018.1543186

Borrachero, A. B., Brígido, M., Mellado, L., Costillo, E., & Mellado, V. (2014). Emotions in prospective secondary teachers when teaching science content, distinguishing by gender. *Research in Science & Technological Education*, *32*(2), 182–215. https://doi.org/10.1080/02635143.2014.909800

Bouhlila, D. S. (2011). The quality of secondary school education in the Middle East and North Africa: What can we learn from TIMSS' results? *Compare*, *41*(3), 327–352. https://doi.org/10.1080/03057925.2010.539887

Brígido, M., Borrachero, A. B., Bermejo, M. L., & Mellado, V. (2013). Prospective primary teachers' self-efficacy and emotions in science teaching. *European Journal of Teacher Education*, *36*(2), 200–217. https://doi.org/10.1080/02619768.2012.686993

Brígido, M., Couso, D., Gutierrez, C., & Mellado, V. (2013). The emotions about teaching and learning science: A study of prospective primary teachers in three Spanish universities. *Journal of Baltic Science Education*, *12*(3), 299–311.

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physics, and earth science classes. *Journal of Research in Science Teaching*, *45*(8), 955–970. https://doi.org/10.1002/tea.20249

Bulunuz, M. (2012). Motivational qualities of hands-on science activities for Turkish preservice kindergarten teachers. *Eurasia Journal of Mathematics Science and Technology Education*, *8*(2), 73–82. https://doi.org/10.12973/eurasia.2012.821a

Bulunuz, M., & Jarrett, O. S. (2010). Developing an interest in science: Background experiences of preservice elementary teachers. *International Journal of Environmental Science Education*, *5*(1), 65–84. https://doi.org/10.1007/s12564-016-9457-2

Byrne, B. (2010). *Structural equation modeling with AMOS. Basic concepts, applications, and programming*. Routledge.

Cadime, I., Lima, S., Pinto, A. M., & Ribeiro, I. (2016). Measurement invariance of the Utrecht Work Engagement Scale for students: A study across secondary school pupils and university students. *European Journal of Developmental Psychology*, *13*(2), 254–263. https://doi.org/10.1080/17405629.2016.1148595

Cansiz, M., & Cansiz, N. (2019). How do sources of self-efficacy predict preservice teachers' beliefs related to constructivist and traditional approaches to teaching and learning? *Sage Open*, *9*(4), 1–8. https://doi.org/10.1177/2158244019885125

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching*, *51*(7), 836–869. https://doi.org/10.1002/tea.21150

Carmona-Halty, M. A., Schaufeli, W. B., & Salanova, M. (2019). The Utrecht Work Engagement Scale for Students (UWES-9S): Factorial validity, reliability, and measurement invariance in a Chilean sample of undergraduate university students. *Frontiers in Psychology*, *10*, 1–5. https://doi.org/10.3389/fpsyg.2019.01017

Cavallo, A. M. L., Rozman, M., Blinkenstaff, J., & Walker, N. (2003). Students' learning approaches, reasoning abilities, motivational goals, and epistemological beliefs in differing college science courses. *Journal of College Science Teaching*, *33*(3), 18–23.

Cobern, W. W., & Loving, C. (2002). Investigation of preservice elementary teachers' thinking about science. *Journal of Research in Science Teaching*, *39*(10), 1016–1031. https://doi.org/10.1002/tea.10052

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In N. G. Lederman, & S. G. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 529–556). Routledge.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.

Creswell, J. W., & Plano-Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Davidson, S. G., Jaber, L. Z., & Southerland, S. A. (2020). Emotions in the doing of science: Exploring epistemic affect in elementary teachers' science research experiences. *Science Education*, *104*(6), 1008–1040. https://doi.org/10.1002/sce.21596

Davis, J. P., & Bellocchi, A. (2020). Intensity of emotional energy in situated cultural practices of science education. *Cultural Studies of Science Education*, *15*, 359–388. https://doi.org/10.1007/s11422-019-09931-0

Davis, J. P., Du, J., Tang, J. H., Qiao, L., Liu, Y. Q., & Chiang, F. K. (2020). Uniformity, diversity, harmony, and emotional energy in a Chinese STEM classroom. *International Journal of Stem Education*, *7*(1), 1–15. https://doi.org/10.1186/s40594-020-00232-5

Demerouti, E., Nachreiner, F., Bakker, A. B., & Schaufeli, W. B. (2001). The job demands-resources model of burnout. *Journal of Applied Psychology*, *86*(3), 499–512. https://doi.org/10.1037/0021-9010.86.3.499

Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78–89. https://doi.org/10.1080/00461520902832368

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Eccles-Parsons, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). W. H. Freeman.

Eren, A. (2014). Relational analysis of prospective teachers' emotions about teaching, emotional styles, and professional plans about teaching. *Australian Educational Researcher*, *41*(4), 381–409. https://doi.org/10.1007/s13384-013-0141-9

Eren, A. (2016). Unidirectional cycles of boredom, boredom coping strategies, and engagement among prospective teachers. *Social Psychology of Education*, *19*(4), 895–924. https://doi.org/10.1007/s11218-016-9348-8

Feldman-Barrett, L., & Russell, J. A. (1998). Independence and bipolarity in the structure of current affect. *Journal of Personality and Social Psychology*, *74*(4), 967–984.

Fernández-Río, J., Cecchini, J. A., & Méndez-Giménez, A. (2014). Effects of cooperative learning on perceived competence, motivation, social goals, effort and boredom in prospective primary education teachers. *Infancia y Aprendizaje*, *37*(1), 57–89. https://doi.org/10.1080/02103702.2014.881650

Frenzel, A. C. (2014). Teacher emotions. In E. A. Linnenbrink-Garcia, & R. Pekrun (Eds.), *International handbook of emotions in education* (pp. 494–519). Routledge.

Frenzel, A. C., Goetz, T., Stephens, E. J., & Jacob, B. (2009). Antecedents and effects of teachers' emotional experiences: An integrated perspective and empirical test. In P. A. Schutz, & M. Zembylas (Eds.), Advances in teacher emotion research: The impact on teachers' lives (pp. 129–151). Springer.

Fulp, S. L. (2002). *The 2000 national survey of science and mathematics education: Status of elementary school science teaching*. Horizon Research.

Gilbert, A., & Byers, C. C. (2017). Wonder as a tool to engage preservice elementary teachers in science learning and teaching. *Science Education*, *101*(6), 907–928. https://doi.org/10.1002/sce.21300

Glynn, S. M., & Koballa, T. R. (2006). Motivation to learn in college science. In J. Mintzes, & W. H. Leonard (Eds.), *Handbook of college science teaching* (pp. 25–32). National Science Teachers Association Press.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2007). Nonscience majors learning science: A theoretical model of motivation. *Journal of Research in Science Teaching*, *44*(8), 1088–1107. https://doi.org/10.1002/tea.20181

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science Motivation Questionnaire: Construct validation with non-science majors. *Journal of Research in Science Teaching*, *46*(2), 127–146. https://doi.org/10.1002/tea.20267

Goetz, T., Frenzel, A. C., Pekrun, R., & Hall, N. C. (2006). The domain specificity of academic emotional experiences. *Journal of Experimental Education*, *75*(1), 5–29. https://doi.org/10.3200/JEXE.75.1.5-29

González, A., & Paoloni, P. V. (2015). Engagement and performance in physics: The role of class instructional strategies, and student's personal and situational interest. *Revista de Psicodidactica*, *20*(1), 25–45. https://doi.org/10.1387/RevPsicodidact.11370

Grabau, L., & Ma, M. (2017). Science engagement and science achievement in the context of science instruction: A multilevel analysis of U.S. students and schools. *International Journal of Science Education*, *39*(8), 1045–1068. https://doi.org/10.1080/09500693.2017.1313468

Graesser, A. C., & D' Mello, S. (2012). Emotions during the learning of difficult material. In B. H. Ross (Ed.), *Psychology of learning and motivation* (pp. 183–225). Academic Press.

Haefner, L. A., & Zembal-Saul, C. (2004). Learning by doing? Prospective elementary teachers' developing understandings of scientific inquiry and science teaching and learning. *International Journal of Science Education*, *26*(13), 1653–1674. https://doi.org/10.1080/0950069042000230709

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). *Multivariate data analysis*. Pearson.

Hampden-Thompson, G., & Bennett, J. (2013). Science teaching and learning activities and students' engagement in science. *International Journal of Science Education*, *35*(8), 1325–1343. https://doi.org/10.1080/09500693.2011.608093

Hufnagel, E. (2015). Preservice elementary teachers' emotional connections and disconnections to climate change in a science course. *Journal of Research in Science Teaching*, *52*(9), 1296–1324. https://doi.org/10.1002/tea.21245

Hugo, D., Sanmarti, N., & Aduriz-Bravo, A. (2013). Styles of emotional work of prospective science teachers during their teaching practice. *Enseñanza de las Ciencias*, *31*(1), 153–170. https://doi.org/10.5565/rev/ec/v31n1.606

Jack, B. M., & Lin, H. (2018). Warning! Increases in interest without enjoyment may not be trend predictive of genuine interest in learning science. *International Journal of Educational Development*, *62*, 136–147. https://doi.org/10.1016/j.ijedudev.2018.03.005

Jen, T. H., Lee, C. D., Chien, C. L., Hsu, Y. S., & Chien, K. M. (2013). Perceived social relationships and science learning outcomes for Taiwanese eighth graders: Structural equation modeling with a complex sampling consideration.

International Journal of Science and Mathematics Education, *11*(3), 575–600. https://doi.org/10.1007/s10763-012-9355-y

Jeong, J. S., González-Gómez, D., & Canada-Canada, F. (2016). Students' perceptions and emotions toward learning in a flipped general science classroom. *Journal of Science Education and Technology*, *25*(5), 747–758. https://doi.org/10.1007/s10956-016-9630-8

Jeong, J. S., González-Gómez, D., & Canada-Canada, F. (2019). How does a flipped classroom course affect the affective domain toward science course? *Interactive Learning Environments*, *29*(5), 707–719. https://doi.org/10.1080/10494820.2019.1636079

Kang, J., & Keinonen, T. (2018). The effect of student-centered approaches on students' interest and achievement in science: Relevant topic-based, open and guided inquiry-based, and discussion-based approaches. *Research in Science Education*, *48*(4), 865–885. https://doi.org/10.1007/s11165-016-9590-2

Kazempour, M., & Sadler, T. D. (2015). Preservice teachers' science beliefs, attitudes, and self-efficacy: A multi-case study. *Teaching Education*, *26*(3), 247–271. https://doi.org/10.1080/10476210.2014.996743

Keys, P. (2006). Are teachers walking the walk or just talking the talk in science education? *Teachers and Teaching*, *11*(5), 499–516. https://doi.org/10.1080/13540600500238527

Kingir, S., Tas, Y., Gok, G., & Vural, S. S. (2013). Relationships among constructivist learning environment perceptions, motivational beliefs, self-regulation and science achievement. *Research in Science & Technological Education*, *31*(3), 205–226. https://doi.org/10.1080/02635143.2013.825594

Lam, T. Y. P., & Lau, K. C. (2014). Examining factors affecting science achievement of Hong Kong in PISA 2006 using hierarchical linear modeling. *International Journal of Science Education*, *36*(15), 2463–2480. https://doi.org/10.1080/09500693.2013.879223

Lavonen, J., & Laaksonen, S. (2009). Context of teaching and learning school science in Finland: Reflections on PISA 2006 results. *Journal of Research in Science Teaching*, *46*(8), 922–944. https://doi.org/10.1002/tea.20339

Lin, H. S., Lawrenz, F., Lin, S. F., & Hong, Z. R. (2013). Relationships among affective factors and preferred engagement in science-related activities. *Public Understanding of Science*, *22*, 941–954. https://doi.org/10.1177/0963662511429412

Mahmoudi-Gahrouei, V., Tavakoli, M., & Hamman, D. (2016). Understanding what is possible across a career: Professional identity development beyond transition to teaching. *Asia Pacific Education Review*, *17*(4), 581–597. https://doi.org/10.1007/s12564-016-9457-2

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education*, *27*(6), 649–673. https://doi.org/10.1007/s10972-016-9479-y

Ministry of Education. (2007a). ORDEN ECI/3854/2007, de 27 de diciembre. [Order ECI/3854/2007, of 27 December], Madrid: BOE.

Ministry of Education. (2007b). ORDEN ECI/3857/2007, de 27 de diciembre [Order ECI/3857/2007, of 27 December], Madrid: BOE.

Morrell, P. D., & Carroll, J. B. (2003). An extended examination of preservice elementary teachers' science teaching self-efficacy. *School Science and Mathematics*, *103*(5), 246–251. https://doi.org/10.1111/j.1949-8594.2003.tb18205.x

National Research Council (NRC). (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

Newhouse, C. P. (2017). STEM the boredom: Engage students in the Australian curriculum using ICT with problem-based learning and assessment. *Journal of Science Education and Technology*, *26*(1), 44–57. https://doi.org/10.1007/s10956-016-9650-4

Ng, K., Lay, Y. F., Areepattamannil, S., Treagust, D. F., & Chandrasegaran, A. L. (2012). Relationship between affect and achievement in science and mathematics in Malaysia and Singapore. *Research in Science & Technological Education*, *30*(3), 225–237. https://doi.org/10.1080/02635143.2012.708655

O′Neill, S., & Stephenson, J. (2012). Exploring Australian preservice teachers sense of efficacy, its sources, and some possible influences. *Teaching and Teacher Education*, *28*(4), 535–545. https://doi.org/10.1016/j.tate.2012.01.008

Organization for Economic Cooperation and Development (OECD). (2007). *PISA 2006: Science competencies for tomorrow's world* (Vol. 1: Analysis). OECD.

Organization for Economic Cooperation and Development (OECD). (2009). *Creating effective teaching and learning environments: First results from TALIS*. OECD.

Palmer, D. H., Dixon, J., & Archer, J. (2016). Identifying underlying causes of situational interest in a science course for preservice elementary teachers. *Science Education*, *100*(6), 1039–1061. https://doi.org/10.1002/sce.21244

Peixoto, F., Mata, L., Monteiro, V., Sanches, C., & Pekrun, R. (2015). The Achievement Emotions Questionnaire: Validation for pre-adolescent students. *European Journal of Developmental Psychology*, *12*(4), 472–481. https://doi.org/10.1080/17405629.2015.1040757

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The achievement emotions questionnaire (AEQ). *Contemporary Educational Psychology*, *36*(1), 36–48. https://doi.org/10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., & Perry, R. P. (2005). *Achievement Emotions Questionnaire (AEQ)—user's manual*. University of Munich, Department of Psychology.

Pekrun, R., & Linnenbrink-Garcia, L. (Eds.). (2014). *International handbook of emotions in education*. Routledge.

Pekrun, R., Muis, M. R., Frenzel, A. C., & Goetz, T. (2018). *Emotions at school*. Routledge.

Pekrun, R., & Perry, R. (2014). Control-value theory of achievement emotions. In R. Pekrun, & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 120–141). Routledge.

Perera, L. D. H. (2014). Parents' attitudes towards science and their children's science achievement. *International Journal of Science Education*, *36*(18), 3021–3041. https://doi.org/10.1080/09500693.2014.949900

Perkins, B. A., Satkus, P., & Finney, S. J. (2020). Examining the factor structure and measurement invariance of test emotions across testing platform, gender, and time. *Journal of Psychoeducational Assessment*, *38*(8), 969–981. https://doi.org/10.1177/0734282920918726

Phelps, C. M. (2010). Factors that preservice elementary teachers perceive as affecting their motivational profiles in mathematics. *Educational Studies in Mathematics*, *75*(3), 293–309. https://doi.org/10.1007/s10649-010-9257-2

Plummer, J. D., & Ozcelik, A. T. (2015). Preservice teachers developing coherent inquiry investigations in elementary astronomy. *Science Education*, *99*(5), 932–957. https://doi.org/10.1002/sce.21180

Preacher, K., & Hayes, A. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879

Reilly, J. M., McGivney, E., Dede, C., & Grotzer, T. (2021). Assessing science identity exploration in immersive virtual environments: A mixed methods approach. *Journal of Experimental Education*, *89*(3), 468–489. https://doi.org/10.1080/00220973.2020.1712313

Rennie, L. J., Goodrum, D., & Hacking, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education*, *31*(4), 455–498. https://doi.org/10.1023/A:1013171905815

Riegle-Crumb, C., Morton, K., Moore, C., Chimonidou, A., Labrake, C., & Kopp, S. (2015). Do inquiring minds have positive attitudes? The science education of preservice elementary teachers. *Science Education*, *99*(5), 819–836. https://doi.org/10.1002/sce.21177

Rosenzweig, E. Q., Wigfield, A., & Eccles, J. S. (2019). Expectancy-value theory and its relevance for student motivation and learning. In S. E. Hidi, & K. A. Renninger (Eds.), *The Cambridge handbook of motivation and learning* (pp. 617–644). Cambridge University Press.

Sawtelle, V., Brewe, E., & Kramer, L. (2012). Exploring the relationship between self-efficacy and retention in introductory physics. *Journal of Research on Science Teaching*, *49*(9), 1096–1112. https://doi.org/10.1002/tea.21050

Schaal, S. (2010). Cognitive and motivational effects of digital concept maps in preservice science teacher training. *Procedia—Social and Behavioral Sciences*, *2*(2), 640–647. https://doi.org/10.1016/j.sbspro.2010.03.077

Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and Psychological Measurement*, *66*(4), 701–716. https://doi.org/10.1177/0013164405282471

Schaufeli, W. B., Martinez, I. M., Marques-Pinto, A., Salanova, M., & Bakker, A. B. (2002). Burnout and engagement in university students: A cross-national study. *Journal of Cross-Cultural Psychology*, *33*(5), 464–481. https://doi.org/10.1177/0022022102033005003

Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A confirmative analytic approach. *Journal of Happiness Studies*, *3*(1), 71–92. https://doi.org/10.1023/A:1015630930326

Serrano, C., Andreu, Y., Murgui, S., & Martinez, P. (2019). Psychometric properties of Spanish version student Utrecht Work Engagement Scale (UWES-S-9) in high-school students. *Spanish Journal of Psychology*, *22*(e21), 1–9. https://doi.org/10.1017/sjp.2019.25

Shumow, L., Schmidt, J. A., & Zaleski, D. J. (2013). Multiple perspectives on student learning, engagement, and motivation in high school biology labs. *The High School Journal*, *96*(3), 232–252.

Sinatra, G. M., Broughton, S. H., & Lombardi, D. O. U. G. (2014). Emotions in science education. In R. Pekrun, & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 415–436). Taylor & Francis.

Sorgo, A., Lamanauskas, V., Sasic, S. S., Ersozlu, Z. N., Tomazic, I., Kubiatko, M., & Usak, M. (2017). Cross-national study on relations between motivation for science courses, pedagogy courses and general self-efficacy. *Eurasia Journal of Mathematics Science and Technology Education*, *13*(10), 6597–6608. https://doi.org/10.12973/ejmste/76970

Starr, C. R. (2018). "I'm not a science nerd!" STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly*, *42*(4), 489–503. https://doi.org/10.1177/0361684318793848

Tighezza, M. (2014). Modeling relationships among learning, attitude, self-perception, and science achievement for grade 8 Saudi students. *International Journal of Science and Mathematics Education*, *12*(4), 721–740. https://doi.org/10.1007/s10763-013-9426-8

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics*, *100*(7), 374–379. https://doi.org/10.1111/j.1949-8594.2000.tb18179.x

Tsai, L. T., & Yang, C. C. (2015). Hierarchical effects of school-, classroom-, and student-level factors on the science performance of eighth-grade Taiwanese students. *International Journal of Science Education*, *37*(8), 1166–1181. https://doi.org/10.1080/09500693.2015.1022625

Uçar, F. M., & Sungur, S. (2017). The role of perceived classroom goal structures, self-efficacy, and engagement in student science achievement. *Research in Science & Technological Education*, *35*(2), 149–168. https://doi.org/10.1080/02635143.2017.1278684

Vedder-Weiss, D., & Fortus, D. (2011). Adolescents' declining motivation to learn science: Inevitable or not? *Journal of Research in Science Teaching*, *48*(2), 199–216. https://doi.org/10.1002/tea.20398

Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching*, *50*(8), 952–988. https://doi.org/10.1002/tea.21103

Vedder-Weiss, D., & Fortus, D. (2018). Teachers' mastery goals: Using a self-report survey to study the relations between teaching practices and students' motivation for science learning. *Research in Science Education*, *48*(1), 181–206. https://doi.org/10.1007/s11165-016-9565-3

Verdugo-Perona, J. J., Solaz-Portolés, J. J., & Sanjosé-López, V. (2019). Assessment of pre-service teachers' science knowledge: The case of Valencian Community in Spain. *Revista de Educación*, *383*(1), 133–162. https://doi.org/10.4438/1988-592X-RE-2019-383-404

Volet, S., Jones, C., & Vauras, M. (2019). Attitude-, group- and activity-related differences in the quality of preservice teacher students' engagement in collaborative science learning. *Learning and Individual Differences*, *73*, 79–91. https://doi.org/10.1016/j.lindif.2019.05.002

Wang, T. L., & Berlin, D. (2010). Construction and validation of an instrument to measure Taiwanese elementary students' attitudes toward their science class. *International Journal of Science Education*, *32*(18), 2413–2428. https://doi.org/10.1080/09500690903431561

Weisgram, E. S., & Bigler, R. S. (2007). Effects of learning about gender discrimination on adolescent girls' attitudes toward and interest in science. *Psychology of Women Quarterly*, *31*(3), 262–269. https://doi.org/10.1111/Fj.1471-6402.2007.00369.x

White, A. M., DeCuir-Gunby, J. T., & Kim, S. (2019). A mixed methods exploration of the relationships between the racial identity, science identity, science self-efficacy, and science achievement of African American students at HBCUs. *Contemporary Educational Psychology*, *57*, 54–71. https://doi.org/10.1016/j.cedpsych.2018.11.006

Wigfield, A., Tonks, S. M., & Klauda, S. L. (2009). Expectancy-value theory. In K. Wentzel, & A. Wigfield (Eds.), *Handbook of motivation in school* (pp. 55–75). Erlbaum.

Wigfield, A., Tonks, S. M., & Klauda, S. L. (2016). Expectancy-value theory. In K. Wentzel, & A. Wigfield (Eds.), *Handbook of motivation in school* (pp. 55–74). Erlbaum.

Zembylas, M. (2004). Emotion metaphors and emotional labor in science teaching. *Science Education*, *88*(3), 301–324. https://doi.org/10.1002/sce.10116

Zembylas, M. (2013). Critical pedagogy and emotion: Working through 'troubled knowledge' in posttraumatic contexts. *Critical Studies in Education*, *54*(2), 176–189. https://doi.org/10.1080/17508487.2012.743468

How to cite this article: Membiela, P., Vidal, M., Fragueiro, S., Lorenzo, M., García-Rodeja, I., Aznar, V., Bugallo, A., & González, A. (2022). Motivation for science learning as an antecedent of emotions and engagement in preservice elementary teachers. *Science Education*, 106, 119–141. https://doi.org/10.1002/sce.21686