



THE EMOTIONS ABOUT TEACHING AND LEARNING SCIENCE: A STUDY OF PROSPECTIVE PRIMARY TEACHERS IN THREE SPANISH UNIVERSITIES

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Introduction

Psychology has dealt extensively with affect and emotions. For many years, however, its study of emotions and feelings was seen as being far removed from education, and even more so from the teaching and learning of specific school content. Following Hernández's theory of cognitive-affective molds (Hernández, 2002), however, it is today recognized that the cognitive configures the affective, and vice versa, and the idea of teaching as an emotional practice in which cognitive and affective processes take part is fully accepted by researchers and educators alike (Beijaard et al., 2000; Shapiro, 2010; Van Veen et al., 2005).

As Hargreaves (1998b, p. 558) puts it, "*emotions are at the heart of education.*" Emotions and feelings play a vital role in the development of learning, since the subjective and emotional world that we each create on top of our external reality gives meaning to relationships, and helps us understand the place we occupy in the wider world. In our particular area, the popularity of such authors as Gardner, (2005), Goleman (1996), and Punset (2010) has contributed to sparking interest in the emotions. Punset (2010) even considers that neural circuits are more highly developed in the amygdala than in the cortex rather than the converse, so that emotions have more influence on the cognitive than the cognitive on the emotional.

Otero (2006) notes that there is no human action without an emotion that substantiates it and makes it possible. Emotion is central to decision making (Punset, 2010), something that both teachers and pupils have constantly to do in class. For Tobin, (2012) emotions are a central part of action in science learning, and act as a

Abstract. *A descriptive and comparative study is made of the emotions that prospective primary teachers in three Spanish universities have about teaching and learning the natural sciences, differentiating between approaches to the content of Biology/Geology and Physics/Chemistry. The study was carried out using a closed-response questionnaire which was completed by 315 primary education bachelor's degree students in the Universities of Extremadura, Las Palmas de Gran Canaria, and the Autónoma of Barcelona (UAB). The results showed that in their recall of their secondary education, most of the prospective teachers have positive emotions towards learning Biology/Geology and negative towards learning Physics/Chemistry. With respect to their future teaching in primary education, there predominated positive emotions towards Biology/Geology, and negative emotions towards Physics/Chemistry, except for the UAB students who reported more positive emotions than negative in this latter case. There was an increase of positive emotions in their expectations of their future teaching of all the science content, and a marked decrease in the negative emotions, relative to the emotions that they had experienced as students of these subjects in secondary school.*

Key words: *emotions, preservice primary teachers, science education.*

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social glue that interconnects interests and individual and collective actions. For pupils, decision making becomes especially important when, at the end of their compulsory education, they have to decide on the direction of their future studies (Lavonen et al., 2008). The decline in vocational careers in science has become somewhat worrying in many countries (Rocard et al., 2008). It may be related to the adverse emotional context surrounding science learning in school, in which many pupils have to decide on the future direction of their careers after having had a propædeutic presentation of the sciences focused on the transmission of abstract, predominantly cognitive, concepts with little relevance to their lives outside school (Vázquez & Manassero, 2007).

Despite epistemological progress in the different philosophical orientations concerning the nature of science (Mellado et al., 2006), in science teaching there has reigned an abusive positivist orientation that has, in fact, excluded social, cultural, and emotional factors, branding them as unfit or unscientific in that they oppose the objectivity of science, even though they may be didactically valuable (Alsop & Watts, 2003; Vázquez & Manassero, 2007).

In science education, affective aspects have been investigated far less than cognitive ones. The four International Handbooks of Science Education have no specific chapter devoted to the emotions in science, although this aspect is dealt with in some chapters, usually in relation more with attitudes than with emotions (Bell, 1998; Koballa & Glynn, 2007; Olitsky & Milne, 2012; Simpson et al., 1994; Tobin, 2012; Wubbels & Brekelman, 1998).

From the initial research line on attitudes (Barmby & Defty, 2006; Blalock et al., 2008; García-Ruiz & Orozco, 2008; Hong, 2010; Kind et al., 2007; Mumba et al., 2009; Osborne, Simon & Collins, 2003; Vázquez & Manassero, 2007, 2008, 2011), the study of emotions in the teaching and learning of science emerged first in conferences and then in science education journals. Now, work focused on this subject is becoming ever more frequent (Abrahams, 2009; Dos Santos & Mortimer, 2003; Marbá & Márquez, 2010; Otero, 2006; Ritchie et al., 2011; orgo et al., 2011; Zembylas, 2002, 2004a, 2005).

Constructivism, the predominant theoretical framework in recent decades in the study of conceptual change and pupils' alternative ideas, is also making an approach to emotions. Pintrich et al. (1993) question "*cold change*", and argue for the importance of motivation and the emotions as determinants in science learning. Positive emotional states favour learning, while negative emotional states severely limit the ability to learn (Vázquez & Manassero, 2007). This could be one of the reasons that some gifted pupils with a high cognitive IQ fail in their studies. Conceptual change is both cognitive and affective (Thagard, 2008), and teachers who ignore the affective aspects of learning may limit their pupils' conceptual change (Duit & Treagust, 2012). For Vázquez and Manassero (2011), the attitudinal and emotional factors involved in learning science become increasingly negative with age, so that if no attention is paid to these aspects, then the possibilities of learning decline progressively rather than improve.

Of particular interest is the study of teachers' emotions because of their influence on teaching and on their pupils' learning. As noted by Garritz (2010b), science teaching is charged with emotions, values, and ideals that make teachers identify with their profession. In their job, teachers experience a wide range of emotions that can be influenced by many factors, such as their knowledge, conceptions, attitudes, values, self-efficacy, self-concept, self-esteem, the teaching context, etc. (Alsop & Watts, 2003). These emotions not only affect their own personal satisfaction but also the effectiveness of their work (Darder, 2000) since emotional aspects, which might be seen as irrational from a cognitive standpoint, can influence their actions. Pupils too generally remember their good teachers for qualities they associate with the affective domain – kindness, sensitivity, humour, trust, etc. (Korthagen, 2010). There has been, however, relatively little research into the role affect plays in the life and the classroom behaviour of science teachers (Dos Santos & Mortimer, 2003).

Prospective teachers have beliefs, attitudes, and emotions towards themselves, towards their pupils, and towards the teaching and learning of their different subjects which are the result of the many years they themselves spent in school, and which may influence their future teaching (Mellado et al., 2008). Their early teaching experiences are full of decisions that had to be made, and of very strong emotional events. These events may even have been traumatic since this stage is one of especial vulnerability, and can generate negative emotions such as anxiety, insecurity, irritation, and disappointment. In a study with a novice science teacher, Ritchie et al. (2011b) find that positive emotions are related to the achieve-



ment of positive expectations and the failure of negative ones, whereas negative emotions are related to the failure of positive expectations. Negative emotions in early teaching experiences can fix behavioural strategies that are aimed at control and survival – strategies which are highly resistant to future change. For Oosterheert and Vermunt (2001), the regulation of emotions is a functional component of learning how to teach science. Teacher education constitutes a space in which these issues need to be considered so that prospective and novice teachers can monitor and improve the impact of their emotions on their classroom dynamics. As noted by Day (1999), change in teachers is indeed a matter of the head, but it is also one of the heart, and it will be hard to make changes if they are not compensated affectively and contribute to increasing the teacher's personal satisfaction in their work.

While knowledge is associated with the cognitive domain, the literature has had different interpretations of teachers' conceptions/beliefs and attitudes. A belief is information that a person accepts as true, and attitude is a personal psychological tendency that implies approval or disapproval. Beliefs influence attitudes, and both influence behaviour (Koballa & Crawley, 1985). In science teaching, beliefs have generally been associated with the cognitive domain, and attitudes with the affective and emotional domain (Koballa & Glynn, 2007). Vázquez and Manassero (2007), in referring to the emotional-attitudinal context of teaching, consider the affective component to be the most important feature of attitude. For Dos Santos and Mortimer (2003), the affective is more general, and subsumes emotions, feelings, and moods.

Many authors concur that emotions are the organism's automatic responses to external stimuli, whereas feelings are more permanent. The basic emotions are part of our evolutionary structure as humans, and are essential for the brain to quickly evaluate stimuli so that the organism can respond accordingly and adaptively (Damasio, 2005). Although emotions are automatic, Damasio (2010) considers them not to be deterministic since there is a considerable personalization of emotional responses to stimuli according to culture, upbringing, etc. – "*biology and culture are fully interactive*" (p. 439).

There are a variety of taxonomies for the affective domain, emotions, and feelings. In the present study, we shall be referring primarily to the emotions, although sometimes we shall refer generically to the affective dimension and to feelings. Of the many definitions of emotions, we adopt that put forward by Bisquerra (2000: 63):

"Emotions are reactions to the information we receive in our relationships in the environment. The intensity of the reaction depends on subjective assessments that we make of how this information will affect our well-being. These subjective assessments will involve prior knowledge, beliefs, personal objectives, perception of a challenging environment, etc. An emotion depends on what is important to us." (Translated by the authors.)

One of the most widely used classifications is that which distinguishes between basic or primary emotions and secondary emotions. For Damasio (2005), the primary emotions are fear, anger, disgust, surprise, sadness, and happiness, together with the social emotions sympathy, embarrassment, guilt, shame, pride, jealousy, envy, gratitude, admiration, indignation, and contempt. But one must not forget that the conceptions of emotions may differ between cultures, and that there occur intra-cultural changes over time. The existence of alternative classifications is therefore not at all surprising.

The classification which comes closest to the nature of our study is that presented by Fernández-Abascal et al. (2001). They distinguish three types of emotion. One corresponds to positive, agreeable, emotions which are short-lasting and mobilize few resources in the person's response to them; another to negative, disagreeable, emotions which mobilize many resources for the person to cope with them; and the third to neutral, neither agreeable nor disagreeable, emotions whose function is to facilitate the emergence of subsequent emotional states. Bisquerra (2009) considers fear, anger, sadness, disgust, anxiety, and shame to be negative emotions; joy, love, and happiness to be positive emotions; and surprise to be an example of a neutral emotion. In their study of prospective science teachers in their initial courses of teacher education, Dos Santos and Mortimer (2003) also adopt a positive and negative emotion classification.

The study of the emotions in the context of school science teaching covers both the general aspects addressed by psychopædogy, and specific aspects related to the content of the different subjects taught (Vázquez & Manassero, 2007). Indeed, recent work has stressed the need to differentiate between



the different subjects of science in analysing the emotions (Van der Hoeven Kraft et al., 2011). Our first exploratory studies (Brígido et al., 2010) indicated that there are major differences in the emotions of prospective primary teachers about teaching and learning Physics/Chemistry or Biology/Geology, mostly negative in the former and positive in the latter. Emotions also influence the formation and evolution of a teacher's pedagogical content knowledge, which further adds to the importance of studying the emotions that are related to specific science content (Garritz, 2010b; Kind, 2009; Park & Oliver, 2008; Zembylas, 2004b, 2005).

Another variable that needs to be considered in connection with emotions is gender, since, for instance, Hazari, Tai and Sadler (2007) find that the influence of affective factors differs between boys and girls. It has been shown that girls have more negative attitudes than boys towards physics and chemistry (Britner, 2008; Christidou, 2011; Vázquez & Manassero, 2007, 2008). An objective of the present work was therefore to determine whether there are any differences in the emotions concerning the teaching and learning of science between men and women prospective primary science teachers.

The Research Problem

In this work, we set out to analyse the emotions of prospective primary teachers about the teaching and learning of science. Although attitudes influence emotions, and emotions produce changes in attitudes (Briñol et al., 2010), the focus of the present study is on emotions, not on attitudes.

In secondary education in Spain, teachers and curriculum subjects are grouped into two separate departments: Biology/Geology and Physics/Chemistry. Our previous work in this context (Brígido et al., 2010) indicated that there was a need to differentiate between the content of Biology/Geology and Physics/Chemistry. One objective therefore was to confirm the influence of such content. The sample was also expanded to three Spanish universities: the Autònoma of Barcelona, that of Extremadura, located in two socio-economically different Regions, and that of Las Palmas de Gran Canaria, in the Canary Islands, a Region that differs from the other two in its being insular.

To summarize, the questions addressed in the present work are:

1. What emotions do the prospective primary teachers recall about their learning of Science in primary school and of Biology/Geology and Physics/Chemistry in secondary school?
2. What emotions do the prospective primary teachers expect to have in their future teaching of the primary school content of Biology/Geology and Physics/Chemistry?
3. Do the emotions differ according to gender and to the speciality they studied in secondary school?

Research Methodology

Sample

The participants in the study were 315 undergraduate students in the Primary Teacher Education courses of three Spanish universities: 56 in the Science Education Faculty of the Universitat Autònoma of Barcelona (UAB), 188 in the Education Faculty in Badajoz of the Universidad de Extremadura (UEX), and 71 in the Teacher Training Faculty of the Universidad de las Palmas de Gran Canaria (ULP). Data were acquired in the first year of the degree courses in the UEX in the 2009-10 academic year and in the ULP in the 2010-11 academic year, and in the second year of the degree course in the UAB in the 2010-11 academic year. During their university course, prospective teachers have to carry out practice teaching in Primary schools. At the time of data acquisition, however, they had yet to do this Practicum.

By gender, there were 223 (70.8%) women in the sample and 92 (29.2%) men, figures representative of the greater proportion of women in primary education courses. Most were younger than 20 years old (62.3%), followed by ages between 21 and 25 (26.8%). Regarding their specialization in secondary education, most had studied Humanities and Social Sciences (64.3%), with fewer having studied Science and Health Sciences (22.2%). The remainder (13.5%) had studied other specialities, and were eliminated from further analysis in the study as being of little significance for the objectives of the work.



Data Collection and Analysis Procedures

This work is characterized as being a descriptive exploratory study using data acquired from a questionnaire. The initial questionnaire consisted of 27 positive and negative emotions, chosen on the basis of previous work (Bisquerra, 2009; Fernández-Abascal et al., 2001), from which the respondent identified the emotions that they felt when they were pupils in primary education learning the content of Science, and in secondary education learning the content of Biology/Geology and Physics/Chemistry. The questionnaire was completed with the emotions they believe they will experience as future primary school teachers in teaching Biology/Geology and Physics/Chemistry content. After a pilot study, we eliminated some emotions and replaced others by synonyms that the students would find more easily understandable. We also added "motivation" because, although it might not be considered an emotion, it is known to be closely related (Bisquerra, 2005), and "boredom" at the suggestion of both instructors and students during the validation process. The final questionnaire consisted of 24 emotions randomly distributed into different tables.

The questionnaire was subjected to validity and reliability tests. These comprised an expert assessment, a pilot study with interviews, and a Cronbach's alpha reliability analysis. This last gave a result of 0.82, implying "good reliability" according to the intervals of the value given by George and Mallery (1995).

The questionnaires were given collectively within regular class time. There was a relaxed atmosphere while they were being completed, with excellent collaboration on the part of the students who, in all cases, showed themselves to be very interested and engaged with the process. The duration of each session was about 20 minutes.

The raw data were subjected to the necessary processes of removing artefacts, coding (identification of the participants and their choices on the questionnaire items), and digitization of the records for their subsequent analysis using the SPSS (Statistical Product and Service Solutions) software package v17.0.

Results of the Research

Emotions about Learning Science in Primary and Secondary School

The prospective primary teachers' recall of their primary school subject of Science consisted of positive emotions, especially curiosity, enthusiasm, and interest (Figure 1). In contrast, only a small fraction recalled such negative emotions as frustration, anger, or anxiety. There were no significant differences between the three universities as determined by an ANOVA, although the ULP prospective teachers reported a slightly greater percentage of negative emotions than those of the other two universities, especially nervousness. The UAB students expressed hardly any negative emotions at all.

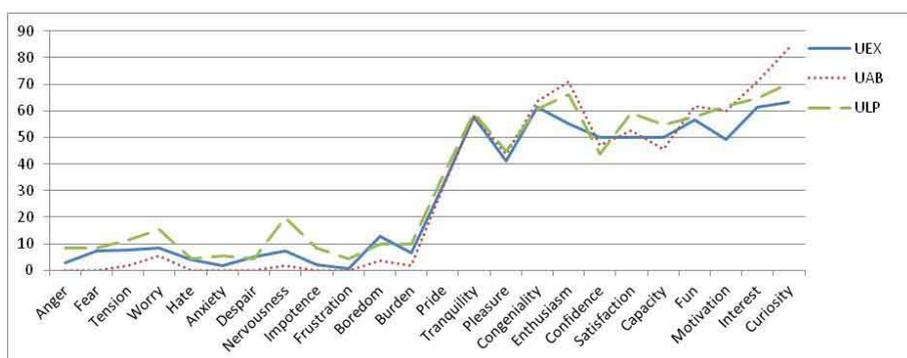


Figure 1: Percentage prevalence of the emotions in learning Science in primary school.

An ANOVA and Student's *t*-test showed there to be no statistically significant differences between the means by gender or by secondary education speciality studied.



For the prospective teachers' secondary education, we distinguished between their recall of the emotions they felt as pupils in learning Physics/Chemistry and those they felt learning Biology/Geology. For the Physics/Chemistry content, the emotions they recalled were very negative, the most reported being tension and nervousness, and the least, tranquillity and pride (Figure 2). An ANOVA showed no significant differences in positive emotions between the three universities, although the percentage was greater in the UAB, for whose students there stood out pleasure, satisfaction, interest, and curiosity. The differences were more significant for the negative emotions, with the lowest percentage for the UAB students also standing out. For the UEX students, tension, worry, despair, and burden were reported by over 60%, and fear, nervousness, and boredom by over 50%. For the ULP students, tension exceeded 60%, and fear, anxiety, nervousness, impotence, and burden exceeded 50%, whereas worry was reported by fewer than 20%. In the UAB case, only tension was reported by 50% and boredom by 40%, whereas, unlike the other two universities, anger, hate, and burden were reported by fewer than 20%.

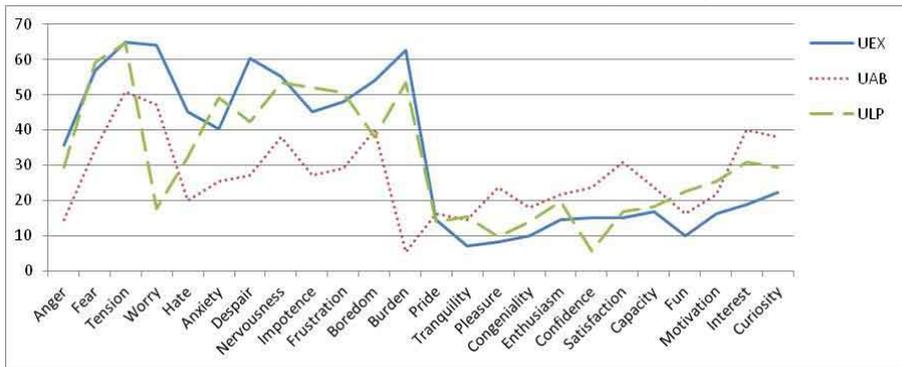


Figure 2: Percentage prevalence of emotions in learning Physics/Chemistry at secondary school.

The Student's *t*-test and the ANOVA showed significant differences in the means by secondary school speciality, but not by gender. In particular, the students who had studied Humanities and Social Sciences in secondary education experienced more negative emotions when they were learning Physics/Chemistry (despair, impotence, frustration, boredom, and burden) than those who had studied Science and Health Sciences.

On the contrary, the emotions they remembered from their time as secondary pupils when learning the content of Biology/Geology were mostly positive, especially tranquillity, congeniality, interest, and curiosity (Figure 3). Of the negative emotions, the most reported were worry, nervousness, and boredom, all of which, however, were at much lower percentages than the positive emotions. There were hardly any significant differences between the three universities. The UAB students presented slightly a higher percentage of positive emotions and lower of negative emotions, with over 65% of them noting interest and practically none noting burden.

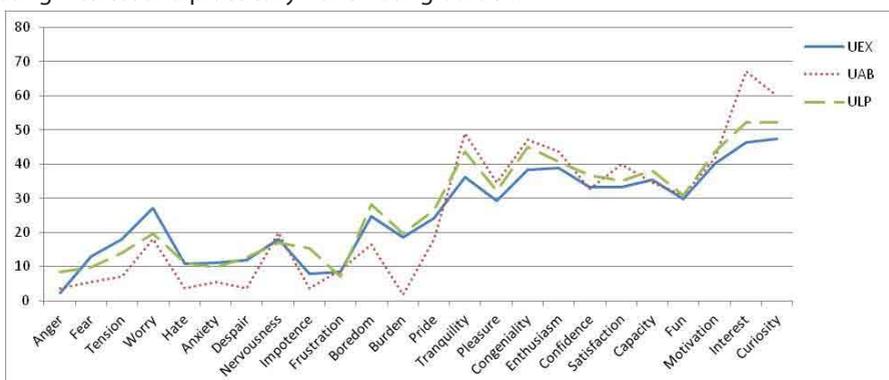


Figure 3: Percentage prevalence of emotions in learning Biology/Geology in secondary school.



The Student's *t*-test and the ANOVA again showed significant differences in the means by secondary education speciality, but not by gender. Which secondary education speciality they had studied, however, was indeed a significant predictor of the emotions they had experienced learning sciences at school. When they had been studying Physics/Chemistry, the Humanities and Social Sciences educated students experienced more negative emotions such as despair and frustration than those who had taken the Science and Health Sciences path through secondary education. Also, the latter group of participants reported more positive emotions, such as enthusiasm and interest, than their Humanities and Social Sciences counterparts.

Emotions about the Future Teaching of Sciences in Primary School

In primary education, science content forms part of a single subject. In the present study, however, we differentiated content related to Physics/Chemistry from that related to Biology/Geology, asking the prospective primary teachers to indicate the emotions they thought they would experience when they had to teach the content of Science related to these two subjects.

Regarding the emotions they expected in their future teaching of Physics/Chemistry content, an ANOVA showed there to be significant differences between the three universities (Figure 4). The UEX and ULP students reported mostly negative emotions, especially in the UEX case, with fear, tension, worry, and nervousness being the emotions most often reported for both universities. In the UAB case, the emotions the students expected were mostly positive, with only tension and nervousness exceeding 30%, whereas enthusiasm exceeded 40%, and fun, motivation, and interest were around 60%.

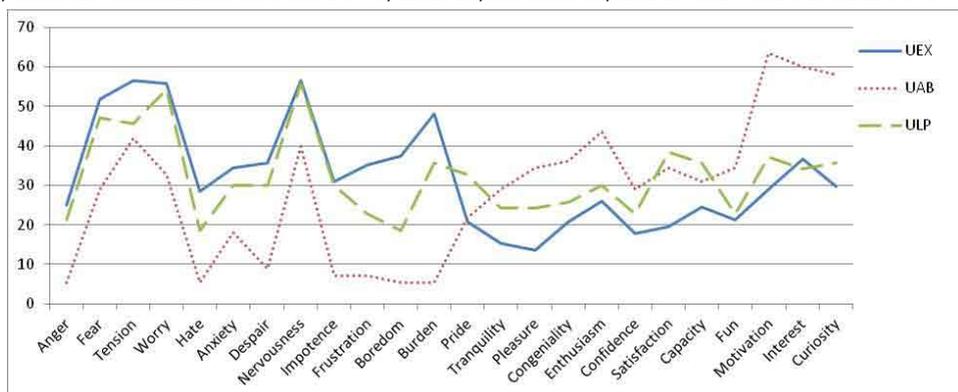


Figure 4: Percentage prevalence of emotions expected in the future teaching of Physics/Chemistry content.

Comparing these results with the emotions experienced when learning these subjects in secondary school (Figure 2), one finds a certain correlation between them for all three universities. Nevertheless, the negative emotions expected as future teachers were reported less frequently than those the students recalled from when they were secondary school pupils learning Physics/ Chemistry, and the positive emotions were reported more frequently.

The Student's *t*-test and the ANOVA again showed significant differences in the means by secondary education speciality, but not by gender. In particular, the students who had studied Science and Health Sciences in their secondary education experienced more positive emotions in teaching Physics/ Chemistry content (enthusiasm, motivation, and interest) than those who had studied Humanities and Social Sciences. The latter, on the contrary, recalled feeling more negative emotions such as fear, tension, worry, and nervousness.

With respect to their future teaching of Biology/Geology content, the emotions they expected were mostly positive (Figure 5). Indeed, all the positive emotions surpassed 40%, with motivation, interest, and curiosity surpassing 60% in all three universities. On the contrary, the emotions they expected to



hardly ever experience were anger, hate, despair, impotence, frustration, and boredom. In this case, the ANOVA showed no significant differences between the three universities.

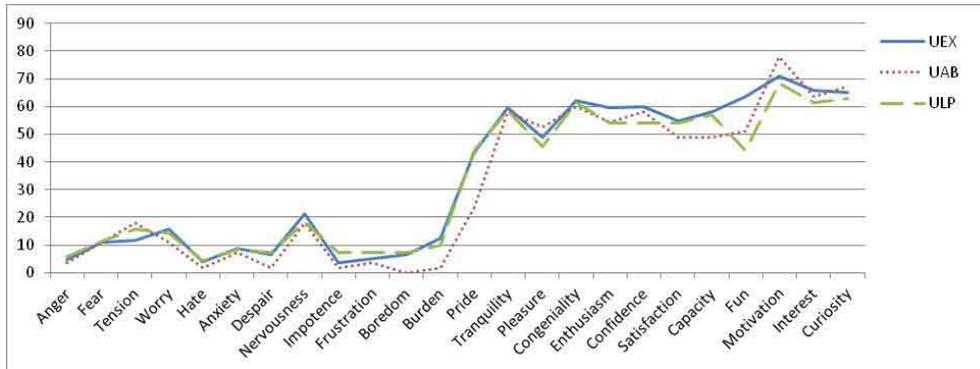


Figure 5: Percentage prevalence of emotions expected in the future teaching of Biology/Geology content.

Even though the emotions the students recalled from learning Biology/Geology in secondary school were already mostly positive (Figure 3), there was still a marked increase in the prevalence of positive emotions in their expectations of their future teaching of this content, and a marked decrease in the negative emotions.

The Student's *t*-test and the ANOVA showed significant differences in the means by both gender and secondary education speciality. The men students experienced more positive emotions, such as pride and pleasure. Also, the students who had specialized in Science and Health Sciences in their secondary education experienced the emotion of pride, an emotion that was not reported by those who had studied Humanities and Social Sciences.

Discussion

The results show that the prospective teachers experienced mostly positive emotions as primary school pupils when they were studying Science. This was most pronounced in the UAB students who recalled hardly any negative emotions when they were learning science in primary school. The ULP students recalled having experienced a slightly greater proportion of negative emotions than the other two groups.

The emotions towards science learning they recalled from their secondary education were generally less positive than for the primary school case. This is consistent with numerous other research findings that primary pupils usually have interest as well as positive emotions and attitudes towards science, but that these attitudes diminish as they get older, especially during their secondary education (Beauchamp & Parkinson, 2008; Murphy & Beggs, 2003; Osborne, Simon & Collins, 2003; Ramsden, 1998; Vázquez & Manassero, 2008, 2011).

In their recall of their secondary education, there was a major difference between the participants' emotions towards learning Biology/Geology and towards learning Physics/Chemistry, the emotions being predominantly positive in the former case, and negative in the latter. This was especially marked in the UEX and ULP groups of prospective teachers. This is consistent with other work (Brígido et al., 2010; Solbes, 2011) which has found pupils at the stage of compulsory secondary education to have negative emotions and feel rejection and disinterest towards the subjects of Physics and Chemistry, which they find difficult, boring, and of little practical use.

While several studies (Brígido et al., 2010; Britner, 2008; Christidou, 2011; Vázquez & Manassero, 2007, 2008) have found that girls have more negative attitudes than boys towards Physics and Chemistry, other results indicate that, not only are there no differences by gender, but that girls even



achieve better academic results in science subjects (Osborne, Simon & Collins, 2003). As in this last case, in the present study too, gender had no significant influence on the emotions the respondents recalled when they were learning science during their primary and secondary school years.

Which secondary education speciality they had studied, however, was indeed a significant predictor of the emotions they had experienced learning sciences at school. When they had been studying Physics/Chemistry, the Humanities and Social Sciences educated students experienced more negative emotions such as despair and frustration than those who had taken the Science and Health Sciences path through secondary education. Also, the latter group of participants reported more positive emotions, such as enthusiasm and interest, than their Humanities and Social Sciences counterparts.

The Student's t-test and the ANOVA showed significant differences in the means by secondary education speciality. The students who had studied Science or Health Sciences in secondary education experienced more positive emotions when they were learning science in secondary school (congeniality, enthusiasm, satisfaction, interest, curiosity, and motivation) than those who had studied Humanities or Social Sciences. This result is again coherent with the literature, since many pupils who choose Humanities and Social Sciences in secondary school feel a profound rejection of the sciences, especially of Physics and Chemistry (Vázquez & Manassero, 2007).

In their expectations of their future work as primary teachers, there predominated positive emotions towards teaching the content of Biology/Geology, and negative emotions towards teaching the content of Physics/Chemistry. These negative emotions were principally worry and fear, except for the UAB students who reported more positive emotions such as motivation and interest. There was generally some correlation between the emotions remembered as secondary school pupils and those they believe that they will experience as teachers in the future, although there was an increase in the positive emotions and decrease in the negative ones in this latter case. While this result is encouraging, the low proportion of positive emotions related to teaching Physics/Chemistry is still very worrying, especially in the cases of the UEX and ULP students.

Negative emotions towards the teaching and learning of content related to Physics or Chemistry constitute a grave problem for the education system. Together with the results of previous studies about attitudes, such as those of Ribelles, Solbes and Vilches (1995) who describe the difference between attitudes towards Biology/Geology (more positive) and towards Physics/Chemistry (more negative), or of other workers (Marbá & Márquez, 2010; Vázquez & Manassero, 2008) who show that attitudes towards science decline with schooling and that few students are enrolling in Spain in university physics or chemistry degree courses, the present results sound an alert of the need to look deeply into the reasons for this disaffection towards these subjects.

The men students in the present study expected to feel more pride and pleasure in teaching Biology/Geology content, but there were no significant differences between men and women in their expectations in teaching Physics/Chemistry. Also, the prospective teachers who had followed Science and Health Sciences path through their secondary education expected to feel more positive emotions and fewer negative ones towards the teaching of science subjects than their counterparts who had studied Humanities and Social Sciences in secondary school.

Conclusions and Implications

The prospective teachers of the three Universities experienced mostly positive emotions as primary school pupils when they were studying science. In their recall of their secondary education, there was a major difference between the participants' emotions towards learning Biology/Geology and towards learning Physics/Chemistry, the emotions being predominantly positive in the former case, and negative in the latter. The emotions towards science learning they recalled from their secondary education were generally less positive than for the primary school case. In the present study, gender had no significant influence on the emotions the respondents recalled when they were learning science during their primary and secondary school years. However there are significant differences in the means by secondary education speciality: The students who had studied Science or Health Sciences in secondary education



experienced more positive emotions when they were learning science in secondary school than those who had studied Humanities or Social Sciences.

With respect to their future teaching in primary education, there predominated positive emotions towards teaching the content of Biology/Geology, and negative emotions towards teaching the content of Physics/Chemistry, except for the UAB students who reported more positive emotions than negative about teaching Physics/Chemistry. There was more correlation in Biology/Geology than in Physics/Chemistry between the emotions remembered as secondary school pupils and those they believe that they will experience as teachers in the future in these contents. However, in both Biology/Geology and Physics/Chemistry, there was an increase of positive emotions in their expectations of their future teaching of this content, and a marked decrease in the negative emotions, relative to emotions that they had experienced as students of these subjects in secondary school. In the present study, gender had no significant influence on the emotions towards teaching science. There were also significant differences in teaching science, in the means by secondary education speciality.

These results, together with those of earlier studies, indicate the need to develop programs of emotional intervention in initial teacher education (Blanco et al., 2010; Koballa et al., 2008). This would seem to be especially important in subjects like Physics or Chemistry which show themselves to present major cognitive and emotional difficulties for prospective primary teachers. Such a program could help them gain awareness of their possible emotional vulnerability, of their own history as pupils at school, and of how emotions affect the teaching of different science subjects. The inclusion of emotional intervention programs specifically designed to address the different content of the subjects they will have to teach would contribute to their developing, in a metacognitive process, the capacity to act so as to change and self-regulate those emotions in their own learning, as well as in that of their pupils, and in their teaching. If, as indicated by Bisquerra and Pérez (2007), academic knowledge is best learned when the pupils have emotional competences as an underlying support, then it is essential, through intervention programs that include both the cognitive and the affective, to form teachers who are themselves emotionally competent, and who know how to diagnose and self-regulate their emotions (Efklides, 2009; Shoffner, 2009).

The research agenda on emotions in the learning and teaching of science is clearly open, with many more questions than answers. Further research is needed with larger samples, using both quantitative and qualitative approaches, to examine the causes of those emotions, and further refining the focus onto specific content (Physics is not the same as Chemistry, and neither is Biology the same as Geology) and the different activities and strategies for teaching and learning. There is also a need to consider how content and different teaching strategies are related to other constructs such as pædagogical content knowledge, self-efficacy, self-concept, self-regulation, metaphors, etc. (Brígido et al., in press; Mellado, Bermejo & Mellado, 2012).

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