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Looking for the emotional footprint of climate change in young people: connections with education, information sources and climate action

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Abstract

Understanding the emotional impact of climate change (CC), its education and communication processes on young people is essential to identify what motivates their engagement in climate action. We have analysed the emotional experiences of secondary school students in the south of Spain (N = 1,050) to develop a tool for exploring the emotional impact of CC, and its relationship to processes of climate education, communication and participation among young people. While there is no clear emotional bias towards CC in the overall sample, significant differences in these experiences depend on the variables listed above. Formal education (educational grade and curricular greening) tends to increase worry, powerlessness and fear, and decrease positive emotions. Frequently, the use of information sources, such as traditional media, specialised sources and social networks is associated with higher emotional intensity. Social networks are a powerful influencer, while traditional media and specialised sources present barriers to access. Participating in climate action (climate movements, climate strikes, environmental groups' activities and school's voluntary activities) has a clearly negative emotional footprint among the group studied.

Introduction

Many international studies and reports (Huq 2022; IPCC 2023; Kolbert 2022; Otto 2022) emphasise the existence of climate change (CC), one of humankind's most complex, urgent, and challenging problems. This problem is currently impacting a considerable part of the world. These consequences include intensified frequency and severity of extreme weather events, variability of weather patterns, and the rise of sea levels (IPCC 2023). The terrestrial biosphere preservation, and ultimately human survival are endangered because of these

consequences (Guillard, Navarro, and Fleury-Bahi 2019; Schneider, Zaval, and Markowitz 2021).

Currently, there are international agreements that legally bind countries to address CC, such as the Paris Agreement (which aims to limit global warming to below 2 °C above pre-industrial levels) or the 2030 Agenda for Sustainable Development, specifically in the Sustainable Development Goal (SDG) 13, which focuses on taking urgent action to combat CC and its impacts (SDG 13: Climate action). However, the World Meteorological Organization (World Meteorological Organization [WMO] 2021) and IPCC reports every year demonstrate a progressive increase in the concentration of greenhouse gases in the Earth's atmosphere (IPCC 2023; WMO 2023a). The continuation of this situation could lead us towards irreversible climate tipping points (Jorgerson et al. 2019; Raftery et al. 2017). Northern countries (which bear most historical responsibility for emissions) have been repeatedly criticised by governments, scientific organisations and youth climate activists for their lack of action to reduce greenhouse gas emissions (Corral-Verdugo 2021; Raftery et al. 2017; Rosen 2015).

According to Neas (2023), young people who have been informed through scientific discourse have reportedly developed feelings of fear and powerlessness towards CC, which can limit their motivation to participate in climate action. This pattern is also seen in the education system, where studies such as Jones and Davison (2021) point to educational experiences of CC that produce feelings of disempowerment and frustration among young people.

The demographic research carried out in Spain by González-Anleo (2024), shows that 82% of those surveyed agree or strongly agree that educational centres should provide more education on environmental issues; it is particularly relevant that 44% of those surveyed explicitly stated that they would have liked to learn more about CC. However, the provision of effective climate education is hindered by the structural organisation of learning in schools, with timetables and the isolation of subjects in schools exacerbating the difficulty of crossing disciplinary boundaries (Beasy et al. 2023; Reid 2019a, 2019b).

Recent studies (Monroe et al. 2019; Rousell and Cutter-Mackenzie 2020) highlight the importance of promoting innovative and disruptive education programming (such as drama, Meira et al. 2022; or escape room, Ouariachi and Van Dam 2022), established quality teaching materials (such as video games, Van Schaik 2023), and contributing to climate action initiatives (such as those reported by Monroe et al. 2019 and Tschakert et al. 2023) to address CC. These resources can evoke emotional responses in learners, including fear and hope, so recognising such emotions is crucial. Excellent research demonstrates the mobilisation of emotions as a crucial dimension to stimulate and enhance climate literacy, boundary awareness and personal engagement with the environment (Martin et al. 2023; Ramadan et al. 2023; Remling 2023).

The aim of the present study is to investigate and improve the understanding of the emotional 'footprint' of CC in young people. The research is based on a quantitative study of the reported emotions experienced by secondary school students in Spain concerning this issue. It also aims to identify and explore

possible emotional patterns in relation to formal learning processes, information sources and involvement in climate activism. Specifically, the following research questions will be addressed:

1. What characterises the emotional experiences of Spanish adolescents in relation to climate change?
2. What are the interrelationships between progression through the Spanish educational system and the emotional experience of adolescents in Spain in relation to climate change?
3. What characterises the relationship between curricular greening and the emotional experience of Spanish adolescents towards climate change?
4. Is there a positive correlation between the frequency of consultation of information sources on climate change and the level of emotional intensity reported by Spanish adolescents on this issue?
5. What sources of information are related to greater changes in emotional intensity regarding climate change among Spanish adolescents?
6. What is the nature of the relationship between adolescents' participation in climate action initiatives and their emotional responses to climate change?

The aim is to create a tool that can be used to assess the emotional impact of educational-communicative processes in young people aged 12–17. The results will be applied to educational programmes and interventions.

Literature review

Changes in climate

During the northern summer of 2023, thermometers placed globally recorded temperatures that have never been seen in human history. These temperatures were significantly higher than the more conservative predictions made by the models used in the IPCC's latest reports (Intergovernmental Panel on Climate Change [IPCC], 2018; IPCC 2023). Climate data gathered by the WMO in collaboration with the European Union's Copernicus CC Service [European Union's Copernicus Climate Change Service [ECMWF] 2023] revealed that June's heatwave broke the record for the hottest month on record (WMO 2023a). This trend is continuing in July, with the temperatures in the northern hemisphere reaching similar or higher levels. According to the Director of the Climate Service of the WMO, we are experiencing uncharted territory, and we can expect more temperature records to be broken as 'El Niño' continues to run its course (WMO 2023b).

Spain is among the most affected countries in the Northern Hemisphere. The whole Iberian Peninsula is experiencing extreme temperatures, especially the provinces with a Mediterranean climate, including those bordering the Mediterranean Sea and three inland provinces (Seville, Cordoba and Jaen). This type of climate is very intense in the area of the Guadalquivir Valley in Andalusia (territorial context of the study), commonly known as the 'frying pan' of Spain

(Deng and Fu 2023; Fogt and Marshall 2023; Hidalgo et al. 2023). The temperatures recorded between June, July and August 2023 in the provinces in this area have given Spain the dubious honour of being one of the two countries, along with Italy, with the highest temperatures recorded during the recent heatwave (WMO 2023b).

There is currently no scientific debate on the existence and human origin of CC (IPCC 2023). Some authors even claim that the Earth is now entering in a new geological epoch, the Anthropocene, characterized by human impact on our planet (Rockström 2022). The coordination, urgency and scale required to reduce this global challenge and adapt to its consequences are unprecedented in history (WMO 2023a, 2023b).

The concern, indignation and mobilisation of young people

Recently, the significant role of young people in mobilising against climate inactivity has been recognized globally. They are organising around newly formed pro-environmental groups or student movements, channelling their concerns and recognising the power they can have as agents of eco-social change (Thunberg 2020a, 2020b). Informed young people openly express generational conflict and life tensions; using public protest as an emotional outlet, aware of potential threats and risks due to CC (Aczel and Makuch 2023; Bright and Eames 2022).

Hickman et al. (2021) conducted a cross-national survey of emotional, cognitive, and functional responses to CC, with representative and comparable samples of young people (aged 16-25) from 10 countries in Africa, the Americas, Asia, Europe, and Oceania. The study found that respondents in all countries expressed high levels of concern, with 59% saying they were very or extremely concerned and 84% saying they were at least moderately concerned. Notably, a significant number of respondents reported negative thoughts about climate change, with 75% expressing fear about the future and 83% believing that humanity has failed to take care of the planet. Given this profile, it is not surprising that the same respondents rated climate change policies negatively and experienced feelings of betrayal and frustration (Hickman et al. 2021). The results of the European Commission's latest special surveys on the social perception of climate change in European societies align with these findings. Among the different groups surveyed (15–24, 25–39, 40–54 and over-55), only the 15–24 age group identified CC as the most serious global problem (European Commission 2023). A deeper understanding of the emotional aspects that motivate young people's climate mobilisation is a necessary and unexplored area of research (Jones and Davison 2021).

An emerging area of research: young people, emotions and CC

Emotions are complex and multidimensional social-psychological processes with an important adaptive purpose and a fundamental component of appraisal (see Table 1 for a list of key emotion-related terms definitions). The perceived relevance of the object or situation to the subject, either on a personal or survival level, greatly influences the outcome of the evaluation; including the type of emotion elicited and its intensity (Fernández-Abascal 2020).

The younger generation has demonstrated a significant perceived relevance to CC, with emotional experiences of an unpleasant nature such as fear, worry and frustration being particularly prevalent, as shown by various demographic studies in the previous section. Furthermore, several studies have also reported increased levels of negative or unpleasant emotions related to CC among students, including high levels of anxiety, depression, fear and sadness (Brügger et al. 2020; Hyry 2019; Martin et al. 2023; Nairn 2019; Pihkala 2022; Poma 2019; Ramadan et al. 2023). Jones and Davison (2021) qualitative study found three main emotional themes towards CC in the life stories of 16 young adults aged 18–24: feeling disempowered, stranded by the generation gap, and anxious about the future. Most of the participants in Jones and Davison (2021) study also reported feeling disempowered by their educational experiences at CC, expressing feelings of abandonment by older adults due to a perceived generational gap, with associated feelings of anger and betrayal. Conversely, high levels of pleasurable emotions such as hope, pride and optimism have been reported in various studies about students' emotions towards CC. These positive or pleasant emotional experiences have been particularly studied and documented among climate activist students, demonstrating how these movements and actions facilitate emotional release and even adaptive Valence transitions of affective experiences (Brosch 2021; Ratinen and Uusiautti 2020). Ojala's (2022) literature review indicates that measures of hope in relation to CC show a consistent positive association with commitment to climate action. On the other hand, in terms of educational communication, Ojala shows that most interventions tend to focus on hopeful messages about the overall progress of CC, a strategy that has not been successful in promoting adaptive hope. A move is required to change the communication model to a practical, solution-focused approach that encourages student empowerment, an area that has not been extensively researched.

Table 1. List of key emotion-related terms definitions.

Term	Definition
Appraisal	Assessment process can occur through associative mechanisms based on previous experiences, which are rapid and automated, and through reasoning mechanisms, which are slower, conscious and controlled (Brosch, 2021). The perceived relevance of the object or situation to the subject, either on a personal or survival level, greatly influences the outcome of the evaluation; including the type of emotion elicited and its intensity (Fernández-Abascal 2020).
Dimensional model of emotion	Approach to emotional classification based on the continuous and subjective nature of emotions, classifying them as “points” in a multidimensional space. The dimensions represent fundamental

	attributes of emotional experience, with the most commonly used being Arousal (ranging from relaxation to high excitement); and <i>Valence</i> , which range from positive or pleasant emotions to negative or unpleasant emotions (Brosch, 2021; Fernández-Abascal 2020).
Emotions	Complex and multidimensional social-psychological processes with an important adaptive purpose. Emotional processing involves a triggering stimulus, an evaluative (appraisal) process, a subjective experience or feeling, physiological effects, expression, and motivational or depressive effects on mobilisation for action (Brosch, 2021; Fernández-Abascal 2020).
Positive or pleasant emotions (<i>Valence</i>)	Type of emotion associated with experiences perceived as pleasurable by the subject, usually associated with the achievement or anticipation of goals (e.g. hope, optimism, joy, amusement). They are associated with the motivation to repeat actions or situations that have elicited the emotional experience. It is unlikely that cognitive resources will be mobilised to generate changes in the subject's behaviour (Brosch, 2021; Fernández-Abascal 2020; Pihkala 2022).
Negative or unpleasant emotions (<i>Valence</i>)	Type of emotion associated with experiences that are perceived as unpleasant by the subject, usually arises when the achievement of a goal is interrupted or compromised, or when the subject perceives a threat at a personal or survival level (e.g. anger, fear, powerlessness, worry). They are associated with the motivation to avoid or combat the situation that has elicited the emotional experience. They require cognitive and behavioural resources to resolve the situation (Brosch, 2021; Fernández-Abascal 2020; Pihkala, 2022).

Methods

The conducted investigation is a survey study analysing quantitative data. The instrument, developed ad hoc, is a third-generation questionnaire implemented in previous phases of the RESCLIMA project, which has undergone several expert revisions and tests (Escoz-Roldán, Gutiérrez-Pérez, and Meira 2019; García-Vinuesa et al. 2019; Meira et al. 2022). The survey consists of seven thematic

blocks (Figure 1), four of which relate to the measurement of independent factors and three relate to dependent factors. This article aims to explore the relationship between four of these thematic blocks, which are described below.

Emotions towards CC: this thematic block comprises eight items, and responses were measured on a scale from 1 (not at all) to 10 (very much). However, to standardise the data, two decisions were made: (1) The means were adjusted to a range of 1–5 points to reduce variability between responses and increase the robustness of the significant differences observed when carrying out inferential analyses. (2), Mean scores delimiting the different quartiles of the sample have been located to provide a new layer of score interpretation and to compare possible group differences with other variables in the study. Based on this analysis, the Emotional Intensity Levels (EIL) interpretation component has been created and classified as follows: very weak ($Q4 \rightarrow \bar{x} \leq 2.58$); weak ($Q3 \rightarrow 2.58 < \bar{x} \leq 3.25$); strong ($Q2 \rightarrow 3.25 < \bar{x} \leq 3.75$), and very strong ($Q1 \rightarrow \bar{x} > 3.75$).

Tests to determine the additivity of the emotional block were conducted using Hotelling's T2 test in conjunction with Tukey's method. The tests were significant at levels below $\alpha = 0.01$, thereby enabling a dimensional analysis to be carried out. Reliability value for Cronbach's alpha on the emotions scale is $\alpha = 0.87$. The design validity of the Emotions Scale is initiated by an open-ended question aimed at identifying the most common emotions experienced by students when learning about CC. The construct validity is supported by the findings of the exploratory factor analysis, which yield two distinct components (Table 2): Positive and Negative emotions. This classification aligns with the Dimensional model of emotions (Table 1), particularly with regard to the differentiation according to emotional Valence (Brosch, 2021; Fernández-Abascal 2020), which enhances the external validity of the Emotions towards CC thematic block.

Educative variables, on the other hand, are dichotomous items that appraise the academic year (1st or 4th), and the association with eco-schools. For more than 30 years, Andalusia has offered public schools the 'Aldea' programme for curricular greening. The programme aims to promote the integrated development of environmental education initiatives in response to the current climate emergency, renaturation, climate change, sustainable development, and the promotion of eco-social competence (Amat, Rammou, and Martín-Ferrer 2024; García, Torres-Porras, and Alcántara-Manzanares 2023). 'Aldea' has two voluntary modalities: Modality A, which is the Andalusian Eco-schools Network, and Modality B, which is environmental education for sustainability. In order to be recognised as an eco-school and participate in Modality A, the centre must meet strict requirements, such as participating in the development of Modality B for at least two years, and at least 50% of the teaching staff must have the necessary training and be actively involved in the development of the programme (Amat, Rammou, and Martín-Ferrer 2024; García, Torres-Porras, and Alcántara-Manzanares 2023).

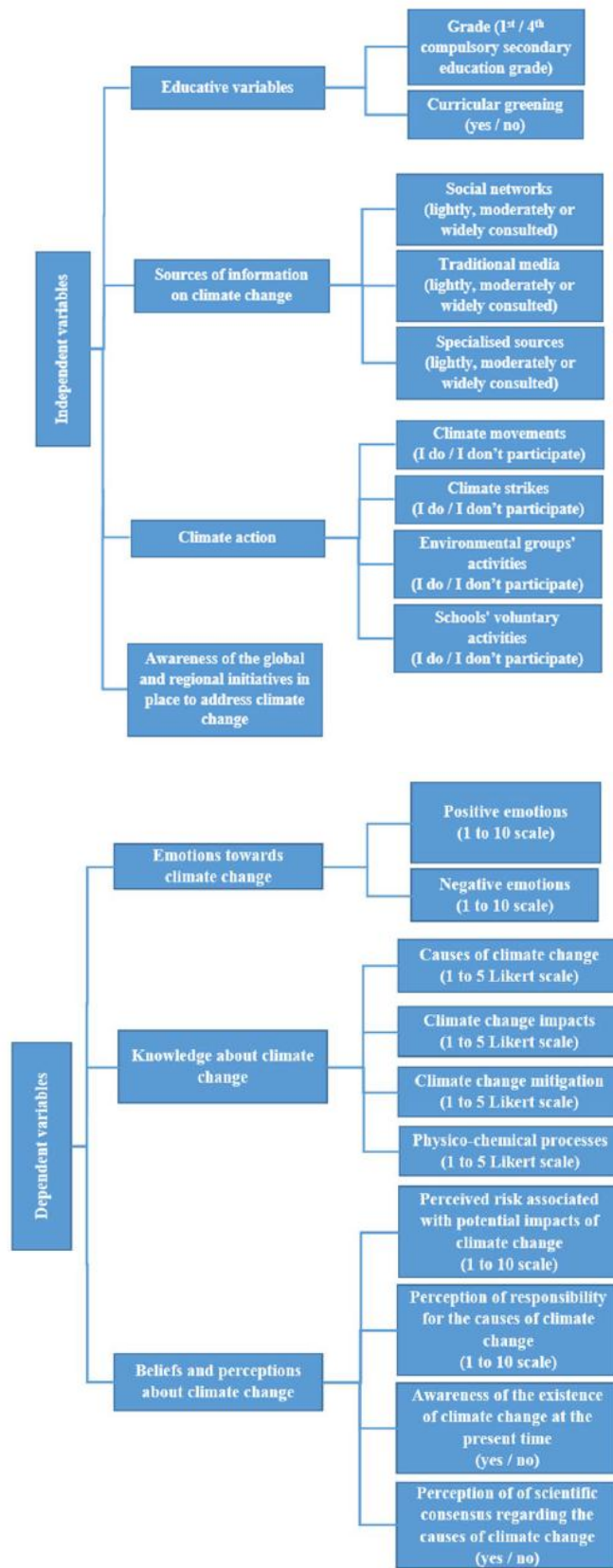


Figure 1. Research instrument: variable typology, blocks, dimensions and response scale.

Table 2. Emotion block principal component analysis.

Emotion	Component-1 Negative emotions	Component-2 Positive emotions
Anger	0.80	-
Fear	0.77	-
Hope	-	0.88
Indignation	0.80	-
Optimism	-	0.86
Powerlessness	0.76	-
Sadness	0.83	-
Worry	0.81	-
Lambda	4.77	1.74
% Variance extracted	49.57	16.93
Composite reliability	0.91	0.86
<i>Note:</i> Only values above 0.30 are included in the factor loadings.		

Sources of information on CC explores the frequency use of three types of media with three response options (lightly, moderately and widely consulted). The sources of information analysed are: Social networks, which include both online (TikTok, Youtube, Twitter [now called X], etc.) and physical networks (friends, family, among others). Traditional media, which include magazines, newspapers, and television. As well as specialised sources, which included professorships, lectures and workshops.

Climate action are dichotomous items that appraise whether the participant had taken part in climate movements (such as Fridays for Future, Extinction Rebellion, etc.), climate strikes, environmental groups' activities on CC, and schools' voluntary activities on CC.

The investigation has been performed in accordance with the principles stated in the Declaration of Helsinki and subjects have provided appropriate informed consent. The survey was anonymous, voluntary, and non-interventional. Therefore, it did not need to be reviewed by an ethics committee, as required by Spanish laws; however, the project involving the research is assessed by the 'Comité de

Ética de la Universidad de Granada, Sección de Investigación con Seres Humanos' with reference number 3252.

A voluntary-stratified sampling scheme was implemented in the eight provinces of southern Spain that constitute the Autonomous Community of Andalusia. The process continued until the required level of gender and grade proportional representativeness was achieved. The final sample included 1,050 students, 56.2% of whom were in the first year of Spanish compulsory secondary education or 7th grade in K-12 educational model (aged 12–13) and 42.8% in the fourth year or 10th grade (aged 15–16), from 26 secondary schools. 50% of the sample identified as female and 50% as male. 71.3% of the students attended schools classified as eco-schools.

The statistical analysis was conducted using the latest version of IBM Statistical Package for the Social Sciences (SPSS). Non-parametric tests (Mann Whitney's U or Kruskal–Wallis) and parametric tests (Student's t-test or Anova) were performed on the data using the law of large numbers to avoid type I/ α (false positives) and type II/ β (false negatives) interpretation errors, reporting only statistically significant results, i.e. those differences that yielded a result of $p < 0.05$ in both tests.

Data analysis and results

Firstly, we present the results of descriptive analyses conducted for the emotions block concerning the CC. Secondly, we analyse the differences between groups for the emotions block in relation to educational variables, sources of information, and climate action blocks. The aim is to deepen the interpretation and understanding of the emotional and perceptual tendencies observed in the population.

The emotional experience of young people in relation to CC

To ascertain the emotional experience of the sample at a general level, different types of descriptive analyses were conducted on the emotions section of the questionnaire. Figure 2 shows the values obtained from these analyses, revealing that the sample attained mean scores that classify their EIL in the weak category ($2.58 < \bar{x} \leq 3.25$) for Dimension 1, Positive Emotions (PE), and its two sub-emotions, Hope and Optimism, as their scores were 3.09 ± 1.13 , 3.11 ± 1.3 , and 3.07 ± 1.27 , respectively.

Similarly, this pattern is also present in Dimension 2, Negative Emotions (NE), and five out of the six emotions that make up the dimension. The emotions in this case are Fear (3.01 ± 1.34), Powerlessness (3.10 ± 1.38), Anger (3.12 ± 1.44), Indignation (3.07 ± 1.39) and Sadness (3.21 ± 1.48). This again indicates a weak EIL, as all of them have average scores between 3.01 and 3.21. The only exception is the negative emotion Worry, for which the secondary school students obtained a mean of 3.71 ± 1.29 out of a maximum of 5. This allows them to reach a higher EIL category, in this case strong ($3.25 < \bar{x} \leq 3.75$).

Formal education: affective bonds mediated by curricular greening and educational grade

This section aims to establish significant differences in mean scores between the students' emotions block and the two items from the educational variables: curricular greening and educational grade. To assess differences related to curricular greening, we will compare students from recognised eco-schools (due to their adherence to 'Aldea') with those who are not. To assess possible differences due to the progression through the educational system (educational grade), the values of first year compulsory secondary education are compared with fourth year students.

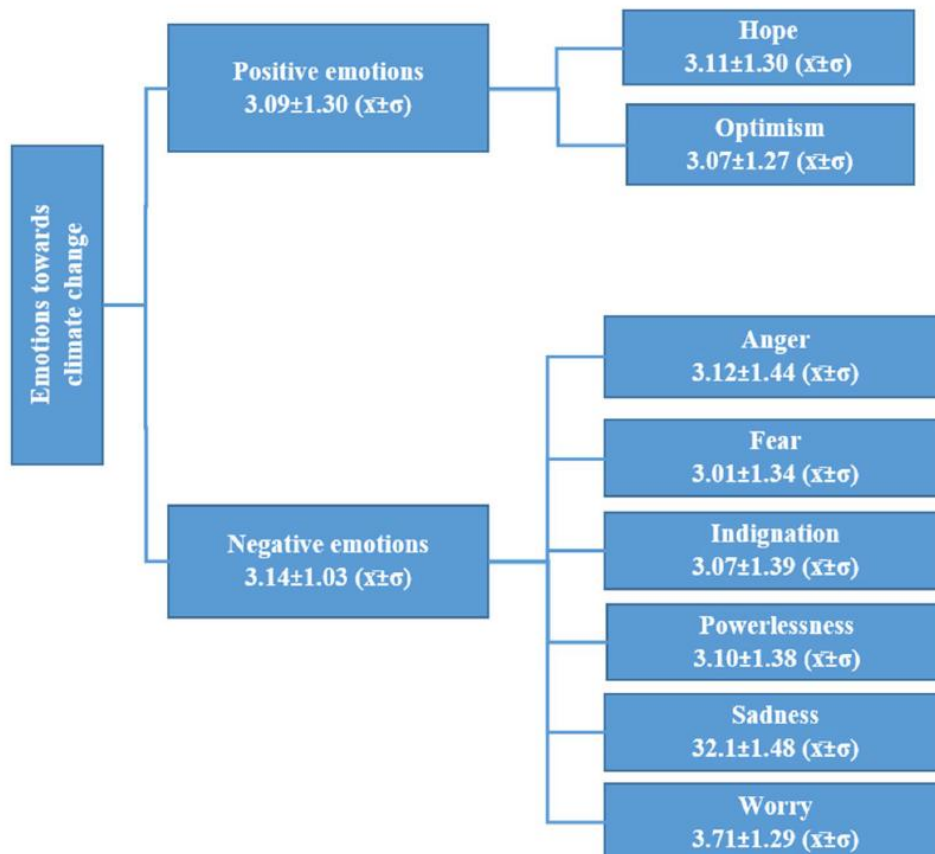


Figure 2. Spanish adolescents' emotional experience of climate change: descriptive statistics.

Table 3 and Figure 3 illustrate significant differences in the greening of the curriculum among the groups mentioned. More specifically, these variations are observed in the dimensions of PE and NE and pertain to emotions such as Hope, Fear and Worry. Particularly, students from non-eco-schools obtain higher mean scores for Dimension 1: Positive Emotions (3.26 ± 1.07) and Hope (3.31 ± 1.32) compared to the students from schools with an environmental curriculum (3.05 ± 1.14 and 3.04 ± 1.30 , respectively). This difference between these groups, in addition to being statistically significant, shows a contrast between the EIL of students from schools without greening in the curriculum (EIL strong) and students from schools with an environmental curriculum (EIL weak) in both PE dimension (3.26 ± 1.07), and Hope (3.09 ± 1.13).

For negative emotions, eco-school students scored higher means in NE dimension (3.12 ± 1.04), Fear (3.08 ± 1.34), and Worry (3.76 ± 1.35), while non-eco-school students scored 2.95 ± 1 , 2.78 ± 1.35 , and 3.50 ± 1.35 , respectively. In this scenario, group variation represents a qualitative shift in EIL related to Worry, which is significantly higher in eco-schools than non-eco-schools.

The results presented in Table 3 and Figure 3 show that there are statistically significant differences in the emotions concerning the educational grade variable. More specifically, there are changes in the mean scores for the PE dimension, its two constituent emotions (Hope and Optimism), and the negative emotion of Powerlessness. Two emotional patterns emerge, similar to the curricular greening.

Table 3. Emotions and curricular greening: inferential tests.

Emotions	Curricular greening		Mann Whitney's U	Student's t-test
	No ($\bar{x} \pm \sigma$)	Yes ($\bar{x} \pm \sigma$)		
Hope	3.31 ± 1.07	3.05 ± 1.14	0.02*	0.02*
Positive emotions	3.26 ± 1.32	3.05 ± 1.30	0.01*	0.02*
Fear	2.78 ± 1.35	3.08 ± 1.34	0.01*	0.01*
Worry	3.50 ± 1.35	3.76 ± 1.28	0.01*	0.01*
Negative emotions	2.95 ± 1	3.12 ± 1.04	0.02*	0.04*

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.05^*$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

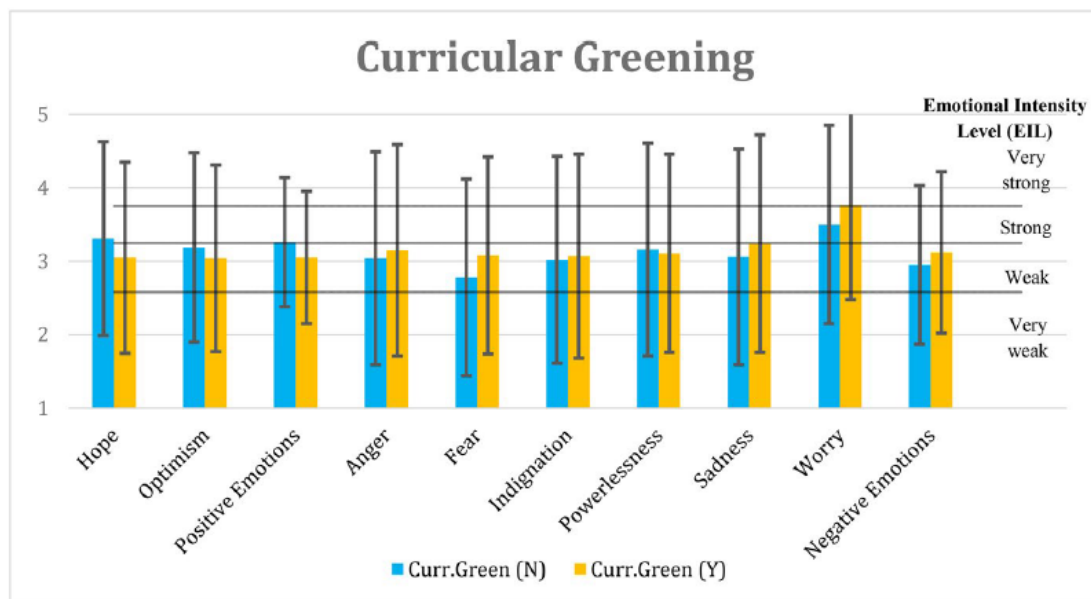


Figure 3. Emotions and curricular greening: means and EIL.

Compared to their peers in higher grades, whose mean scores are 2.96 ± 1.12 , 2.98 ± 1.22 and 2.93 ± 1.25 , respectively, students at the beginning of their education have the highest scores for emotional experiences related to the PE dimension (3.19 ± 1.13), Hope (3.26 ± 1.33) and Optimism (3.13 ± 1.3). Furthermore, this implies a qualitative shift in the EIL between the groups studied for the emotion of Hope, as students in the 1st show a strong EIL, while those in the 4th show a weak EIL.

On the other hand, students in the 4th had a higher mean EIL (3.23 ± 1.37) for the negative emotion of Powerlessness than those in the 1st (2.99 ± 1.37). However, there was no difference in EIL.

Affective experiences and information sources: the role of barriers in relation to typology and frequency of use

This section discusses potential differences in average emotional scores among students based on the frequency of use of three items that make up the sources of information block: social networks, traditional media, and specialised sources, with respect to CC.

First, this section analyses group differences in emotions associated with the frequency of using social networks, including physical and online media, as sources of information about CC. The inferential tests (Table 4) show a clear trend among the students surveyed regarding the use of social networks: the more frequently students reported using this source of information, the higher their average emotional scores were in their self-reports, regardless of their emotional Valence classification.

A closer examination of these increases based on the EIL (Figure 4) shows that changes only occurred in the NE dimension and related emotions. These changes follow two trends:

- ‘Staggered changes’: This group is made up of the items that obtain a higher and consecutive EIL for the different frequencies of use of social networks. This typology groups together NE dimension, Powerlessness, Anger, Sadness and Worry. All of them show a correlation between lightly consulted-very weak EIL, moderately-weak EIL and widely-strong EIL; only Worry has a particular nuance, as it shows the pattern of lightly consulted-weak EIL, moderately-EIL strong and widely-EIL very strong.
- ‘Initial leap and stabilisation’: Composed of all those emotions that increase in EIL only when changing from lightly consulted to moderately or widely consulted. This category corresponds to Fear and Indignation, as they both receive the correspondence scheme of lightly consulted-very weak EIL and, upon rising to moderately/widely consulted, increase to weak EIL.

Table 4. Emotions and educational grade: inferential tests.

Emotions	Grade		Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	1st ($\bar{x} \pm \sigma$)	4th ($\bar{x} \pm \sigma$)		
Hope	3.26 ± 1.33	2.93 ± 1.25	0.00**	0.00**
Optimism	3.13 ± 1.30	2.98 ± 1.22	0.02*	0.04*
Positive emotions	3.19 ± 1.13	2.96 ± 1.12	0.00**	0.00**
Powerlessness	2.99 ± 1.37	3.23 ± 1.37	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.05^*$ and $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

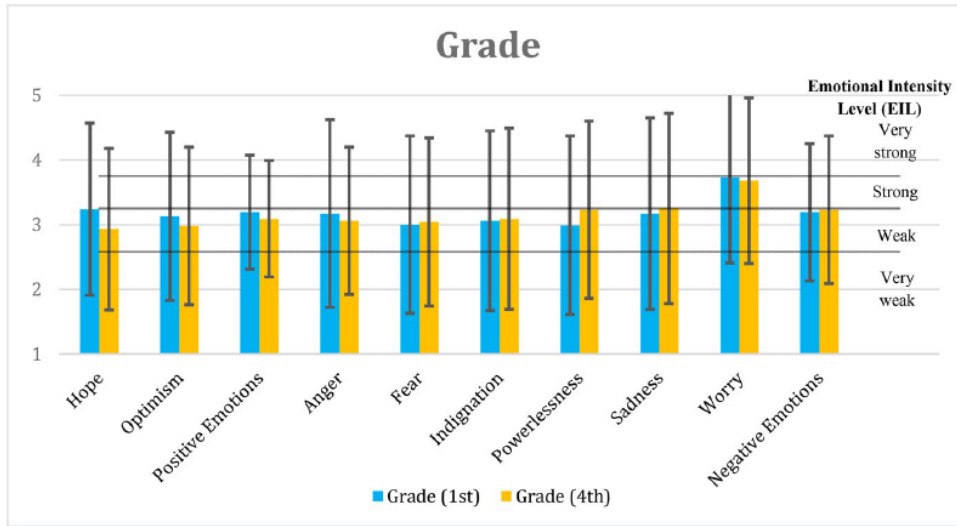


Figure 4. Emotions and educational grade: means and EIL.

Table 5 presents the results of the inferential tests on the frequency of consulting traditional media (magazines, newspapers and television). Similar to social networks, students reporting higher frequencies of traditional media use display a rise in their average emotional scores compared to those using these sources less frequently. However, in this case, the changes in EIL are perceived in both emotional dimensions. The observed patterns of change are as follows (Figure 6):

Table 5. Emotions and information sources/social networks: inferential tests.

Emotions	Social networks			Mann Whitney's U	Student's t-test
	Lightly consulted ($\bar{x} \pm \sigma$)	Moderately consulted ($\bar{x} \pm \sigma$)	Widely consulted ($\bar{x} \pm \sigma$)		
Hope	2.74 ± 1.35	3.05 ± 1.27	3.25 ± 1.30	0.00**	0.00**
Optimism	2.67 ± 1.29	2.99 ± 1.21	3.23 ± 1.28	0.00**	0.00**
Positive emotions	2.70 ± 1.17	3.02 ± 1.09	3.24 ± 1.12	0.00**	0.00**
Anger	2.55 ± 1.47	3.06 ± 1.42	3.32 ± 1.40	0.00**	0.00**
Indignation	2.50 ± 1.37	3.12 ± 1.38	3.20 ± 1.36	0.00**	0.00**
Powerlessness	2.45 ± 1.43	3.08 ± 1.33	3.28 ± 1.34	0.00**	0.00**
Sadness	2.47 ± 1.44	3.19 ± 1.45	3.41 ± 1.45	0.00**	0.00**
Worry	3.03 ± 1.41	3.70 ± 1.28	3.90 ± 1.23	0.00**	0.00**
Negative Emotions	2.56 ± 1.15	3.19 ± 1.06	3.39 ± 1.05	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

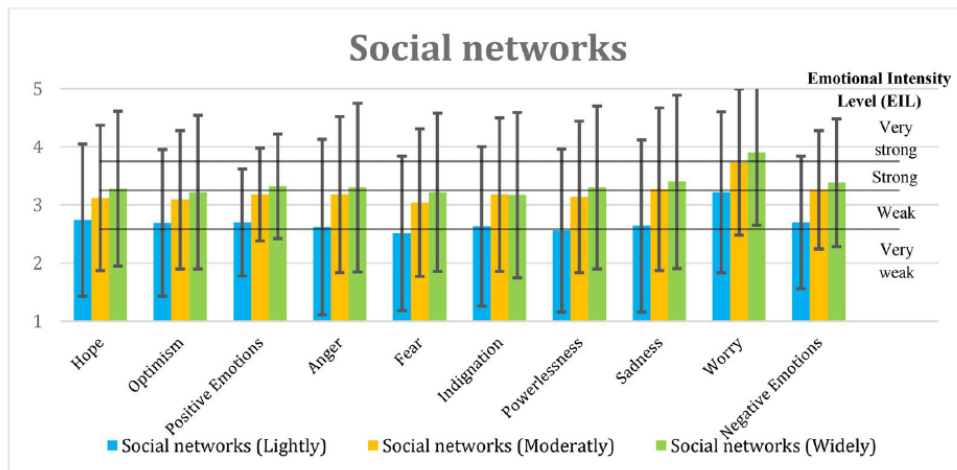


Figure 5. Emotions and information sources/social networks: means and EIL.

Finally, as can be seen in Table 6, group difference tests are carried out on the level of use of specialised sources (teachers, lectures, workshops, etc.). Again, the data show how greater use of these sources of information is reflected in an increase in the mean scores on the emotional self-reports (Figure 7). Similarly to the traditional media, the EIL also shows changes for the two emotional dimensions:

- ‘Staggered changes’: This set includes the negative emotions Fear and Indignation (lightly consulted-very weak EIL, moderately consulted-weak EIL and widely consulted-strong EIL) and the emotion Worry (little consulted-weak EIL, moderately consulted-strong EIL and widely consulted-very strong EIL).
- ‘Initial stabilisation and final leap’: Within this typology we find PE and NE dimensions, as well as the emotions of Hope, Optimism, Powerlessness, Anger and Sadness. All of them receive the correspondence scheme lightly/moderately consulted-weak EIL and widely consulted-strong EIL.

Table 6. Emotions and information source/traditional media: inferential tests.

Emotions	Traditional media			Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	Lightly consulted ($\bar{x}\pm\sigma$)	Moderately consulted ($\bar{x}\pm\sigma$)	Widely consulted ($\bar{x}\pm\sigma$)		
Hope	2.71 ± 1.22	3.10 ± 1.30	3.51 ± 1.31	0.00**	0.00**
Optimism	2.61 ± 1.20	3.07 ± 1.26	3.48 ± 1.21	0.00**	0.00**
Positive Emotions	2.66 ± 1.05	3.08 ± 1.11	3.49 ± 1.13	0.00**	0.00**
Anger	2.86 ± 1.46	3.04 ± 1.4	3.63 ± 1.28	0.00**	0.00**
Indignation	2.68 ± 1.37	3.04 ± 1.37	3.54 ± 1.38	0.00**	0.00**
Powerlessness	2.79 ± 1.41	3.04 ± 1.35	3.58 ± 1.37	0.00**	0.00**
Sadness	2.71 ± 1.49	3.20 ± 1.46	3.67 ± 1.37	0.00**	0.00**
Worry	3.18 ± 1.33	3.73 ± 1.29	4.14 ± 1.13	0.00**	0.00**
Negative Emotions	2.81 ± 1.12	3.17 ± 1.07	3.67 ± 0.99	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

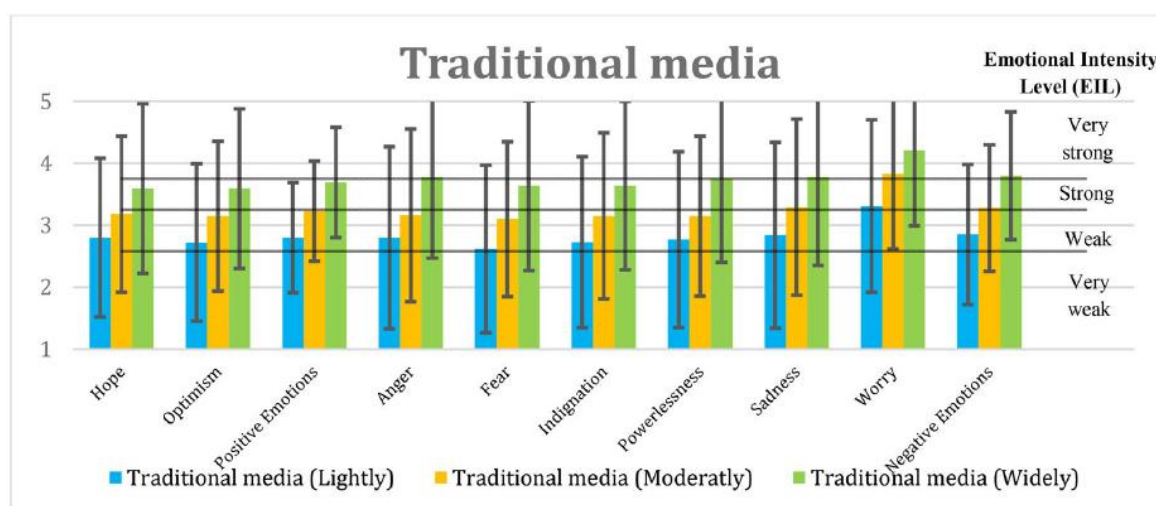


Figure 6. Emotions and information sources/traditional media: means and EIL.

Emotional valence and climate engagement – is there a clear predominance among teenagers?

The concluding set of inferential analyses for the emotions block aims to investigate any significant differences in students' emotional experiences, based

on the four items denoting the climate action commitment. These items assess whether or not students participated in climate movements, climate strikes, environmental groups' activities and schools' voluntary activities.

Table 7 illustrates considerable differences in the mean scores of students for the NE dimension and all its corresponding emotions, based on their participation in climate movements (i.e. Fridays for the Future, Extinction Rebellion, etc.). In particular, it can be seen that students who participate in this type of movement achieve higher mean scores than their peers who do not participate. These variances indicate numerous changes in EIL between the two groups of students, in a more in-depth manner. Students who participate acquire a strong EIL for UE, Fear, Powerlessness, Anger, Indignation and Sadness, whereas students who do not participate acquire a weak EIL. Similar observations can be made for the emotion of Worry, which is classified as a very strong EIL for those who participate and a strong EIL for those who do not.

Table 7. Emotions and information sources/specialised sources: inferential tests.

Emotions	Specialised sources			Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	Lightly consulted ($\bar{x}\pm\sigma$)	Moderately consulted ($\bar{x}\pm\sigma$)	Widely consulted ($\bar{x}\pm\sigma$)		
Hope	2.76 ± 1.29	3.10 ± 1.31	3.35 ± 1.26	0.00**	0.00**
Optimism	2.65 ± 1.26	3.06 ± 1.23	3.35 ± 1.28	0.00**	0.00**
Positive emotions	2.70 ± 1.05	3.08 ± 1.11	3.35 ± 1.13	0.00**	0.00**
Anger	2.59 ± 1.49	3.06 ± 1.41	3.56 ± 1.32	0.00**	0.00**
Fear	2.58 ± 1.34	2.94 ± 1.33	3.45 ± 1.24	0.00**	0.00**
Indignation	2.55 ± 1.42	3.01 ± 1.36	3.53 ± 1.27	0.00**	0.00**
Powerlessness	2.74 ± 1.41	3.02 ± 1.37	3.46 ± 1.29	0.00**	0.00**
Sadness	2.69 ± 1.55	3.16 ± 1.45	3.62 ± 1.36	0.00**	0.00**
Worry	3.10 ± 1.48	3.67 ± 1.26	4.15 ± 1.09	0.00**	0.00**
Negative emotions	2.71 ± 1.17	3.15 ± 1.07	3.63 ± 0.94	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01$ **. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

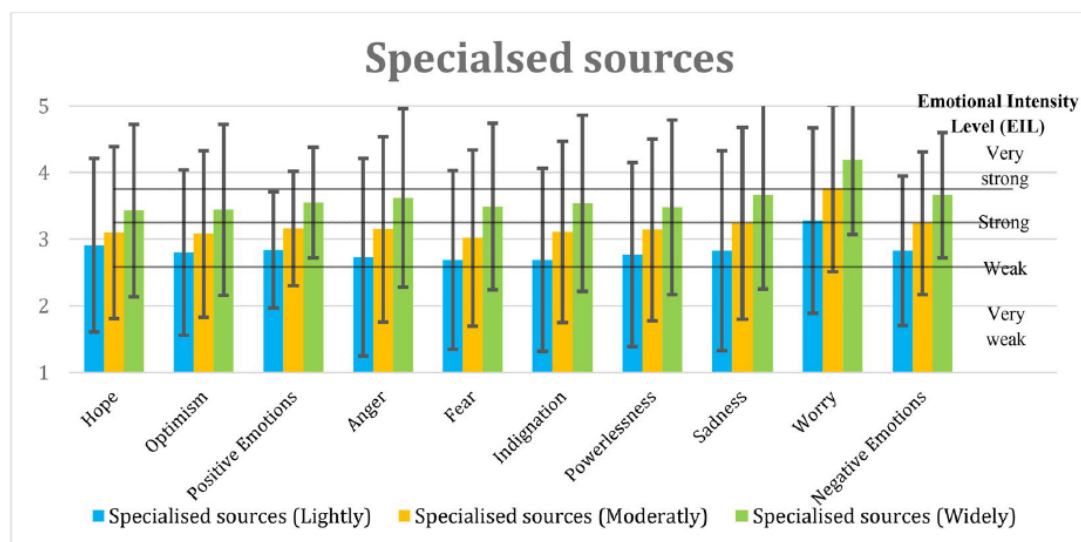


Figure 7. Emotions and information sources/specialised sources: means and EIL.

We also present the results of the inferential tests carried out on participants in the climate strikes, as shown in Table 8. As with the climate movements, participating students demonstrate a general increase in their average emotional

scores compared to those who do not participate. However, significant differences are only observed in the NE dimension with respect to Fear, Anger and Indignation. The students who participated had a strong EIL for UE, Fear, Anger and Indignation, compared to a weak EIL for those who did not.

Thirdly, the differences in mean scores for participation in environmental groups' activities are presented (Table 9). Participation in these activities, once again, leads to a rise in the mean scores of students compared to the ones who do not take part. In this case, as in the case of participation in climate movements, statistically significant differences are observed for NE and all its component emotions. Similarly, differences are also perceived in the EIL of the groups, reaching a strong EIL in NE dimension, Fear, Powerlessness, Anger, Indignation and Sadness, for students who participate, compared those who do no, who show a weak EIL. Additionally, students who participate show a very strong EIL for Worry, compared to a strong EIL for those who do not participate.

Finally, in relation to participation in schools' voluntary activities (Table 10), we can see that this variable has a significant influence on the two dimensions of emotions studied, as well as on all their component emotions. Again, there is a clear tendency for students who participate in these activities to obtain higher scores than those who do not for all the emotions studied. Furthermore, these significant differences are configured in jumps from weak EIL to strong (not participating versus participating) for NE and the emotions Hope, Fear, Powerlessness, Anger, Indignation and Sadness; as well as from EIL strong to very strong for the emotion Worry.

Table 8. Emotions and participation in climate actions/climate movements: inferential tests.

Emotions	Climate movements		Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	I don't participate ($\bar{x} \pm \sigma$)	I do participate ($\bar{x} \pm \sigma$)		
Anger	3.07 ± 1.43	3.56 ± 1.37	0.00**	0.00**
Fear	2.96 ± 1.34	3.45 ± 1.27	0.00**	0.00**
Indignation	3.05 ± 1.26	3.47 ± 1.26	0.00**	0.01**
Powerlessness	3.06 ± 1.36	3.40 ± 1.39	0.00**	0.00**
Sadness	3.15 ± 1.48	3.68 ± 1.32	0.00**	0.00**
Worry	3.65 ± 1.31	4.16 ± 1.06	0.00**	0.00**
Negative emotions	3.15 ± 1.09	3.61 ± 1.03	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

Table 9. Emotions and participation in climate actions/climate strikes: inferential tests.

Emotions	Climate strikes		Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	I don't participate ($\bar{x} \pm \sigma$)	I do participate ($\bar{x} \pm \sigma$)		
Anger	3.05 ± 1.43	3.48 ± 1.41	0.00**	0.00**
Fear	2.97 ± 1.33	3.27 ± 1.24	0.00**	0.00**
Indignation	3.01 ± 1.37	3.38 ± 1.39	0.01**	0.01**
Negative emotions	3.15 ± 1.09	3.44 ± 1.12	0.01**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

Table 10. Emotions and participation in climate actions/environmental groups' activities: Inferential tests.

Emotions	Environmental groups' activities		Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	I don't participate ($\bar{x}\pm\sigma$)	I do participate ($\bar{x}\pm\sigma$)		
Anger	3.04 ± 1.43	3.66 ± 1.40	0.00**	0.00**
Fear	2.96 ± 1.34	3.35 ± 1.31	0.01*	0.01*
Indignation	3.01 ± 1.40	3.46 ± 1.40	0.00**	0.00**
Powerlessness	3.05 ± 1.37	3.40 ± 1.38	0.04*	0.04*
Sadness	3.12 ± 1.48	3.64 ± 1.40	0.00**	0.00**
Worry	3.30 ± 1.31	3.77 ± 1.13	0.00**	0.00**
Negative Emotions	3.13 ± 1.10	3.63 ± 0.97	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.05^*$ and $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

Table 11. Emotions and participation in climate actions/schools' voluntary activities: inferential tests.

Emotions	Schools' voluntary activities		Mann Whitney's <i>U</i>	Student's <i>t</i> -test
	I don't participate ($\bar{x}\pm\sigma$)	I do participate ($\bar{x}\pm\sigma$)		
Hope	3.03 ± 1.30	3.29 ± 1.30	0.00**	0.00**
Optimism	3.02 ± 1.27	3.19 ± 1.27	0.03**	0.03**
Positive emotions	3.03 ± 1.12	3.24 ± 1.13	0.00**	0.00**
Anger	2.98 ± 1.44	3.46 ± 1.39	0.00**	0.00**
Fear	2.87 ± 1.34	3.36 ± 1.27	0.00**	0.00**
Indignation	2.92 ± 1.37	3.43 ± 1.36	0.00**	0.00**
Powerlessness	2.93 ± 1.36	3.49 ± 1.33	0.00**	0.00**
Sadness	3.05 ± 1.48	3.58 ± 1.40	0.00**	0.00**
Worry	3.57 ± 1.33	4.03 ± 1.19	0.00**	0.00**
Negative emotions	3.06 ± 1.10	3.56 ± 1.03	0.00**	0.00**

Note. Only emotions with significant values in one or both inferential tests are included. $\alpha < 0.01^{**}$. The highest mean scores for each item for the different contrast groups have been highlighted in bold text in order to facilitate comparison.

Discussion

The results of the current study show that, overall, the secondary school students surveyed maintain a certain balance between the emotional Valence (positive and negative) and the intensity of the emotions they experience towards CC. The only outlier is Worry, whose average score deviates from the others by about 0.70–0.50 points (3.71), placing it in the strong EIL category ($3.25 < \bar{x} \leq 3.75$). It is worth noting that the sample mean for this emotion is almost identical to that reported by Hickman et al. (2021) in their study of 10,000 young people (16–25 years old) from 10 different countries, where the whole sample score for this emotion was 3.70.

The literature recognises that emotions are multidimensional and complex in nature and are linked to evaluative processes that vary based on the evaluator's perceptions, knowledge, and experiences (Brosch, 2021; Fernández-Abascal 2020). Therefore, a general analysis cannot conclude that there are no emotional Valence predominances in the sample. It is necessary to delve deeper into the variables that differentiate certain segments of the group from others, which may reveal more specific emotional Valence nuances. Moreover, the null presence of items with mean scores close to 0 (absence of the emotion) is congruent with a feature reported in numerous studies with different populations and contexts: the CC can elicit a great variability of emotional experiences and typologies, despite its adverse character (Brosch 2021; Nairn 2019; Pihkala 2022).

Despite this situation of 'emotional statistical equilibrium', it is worth noting that the general sample reported a peak of emotional intensity in terms of Worry.

Worry is an unpleasant or negative emotion characterised by a significant cognitive load (Massoni 2014). It is usually triggered by continuous negative thoughts about an event with an uncertain or adverse outcome. In its adaptive mode, Worry enhances metacognitive processes for decision making, motivates behaviour aimed at eliminating the triggering phenomenon, and generates patterns of protection and prevention against future consequences (Massoni 2014; Sweeny and Dooley 2018). However, for this to be possible, the individual must perceive a certain degree of control over the situation's outcome. Otherwise, they may trigger maladaptive reactions of shock or paralysis (Massoni 2014; Sweeny and Dooley 2018). Kollmus and Agyeman (2002) issued this warning two decades ago, before unprecedented mental health conditions such as ecoanxiety and solastalgia began to be prescribed:

Apathy and resignation are often the result of a person feeling pain, sadness, anger, and helplessness at the same time. If the person has a strong feeling that he or she cannot change the situation (locus of control), he or she will very likely retreat into apathy, resignation, and sarcasm. A person might stop informing himself or herself about environmental issues and focus on different aspects of life. Such a person might still perform some pro-environmental actions out of a feeling of moral obligation but is very unlikely to become very proactive. (p.255)

In this instance, the outcomes obtained from the overall sample suggest that there is a high EIL in Worry. However, there is no co-occurrence of high levels of other emotions, with which the literature indicates a certain affinity, such as Powerlessness, Sadness and Fear. Together with the presence of a statistical balance between positive and negative emotions, this scenario may imply that secondary school students generally perceive some control over the future of CC, fostering an environment that may support adaptive emotional development. However, the knowledge, experiences or behaviours that condition the perceptions of this group are unknown. Therefore, the character that might be present in Worry cannot be specified. In order to clarify the situation, the results of the group differences are discussed below.

Formal education influences the affective experience of CC with a negative/unpleasant emotional footprint

Significant differences in students' emotional experiences based on the variables curricular greening and educational grade are reflected in the inferential analyses for the block of educational variables.

Results suggest a possible pattern in the emotional experience of students in relation to CC for the block of educational variables: those students in higher grades and regularly exposed to systematic environmental education (eco-schools), presumably with specialised training, report an increased negative component in their emotional self-reports compared to their less experienced peers.

An increase in negative emotions and a decrease in positive should not necessarily be interpreted as something negative. The literature associates negative emotions

with an evaluation of an object as adverse to the achievement of goals or one's own survival, and therefore with mobilisation to take action to resolve it (Brosch, 2021; Fernández-Abascal 2020; Pihkala 2022). However, this needs to be coupled with a realistic perception and evaluation of it in order for this to be adaptive. In this case, it is unclear whether this pattern results from a positive or negative influence of education on appraisal inherent to emotional processes.

On one hand, this result shows a possible positive influence of the educational system and curricular greening programmes on the sampled students. This is due to the reduction of positive emotional experiences that may result from insufficient exposure, training and/or knowledge, leading to particularly maladaptive tendencies that discourage action against CC by suppressing the need for appropriate behaviours and action plans. Moreover, the educational variables studied promote the emergence of emotional experiences with a greater presence of negative emotions in students, an emotional typology that the literature associates with a pronounced adaptive character for survival and with a broad potential to promote pro-environmental decisions (Brosch 2021; Brügger et al. 2020; Fernández-Abascal 2020; Hyry 2019). Although it is not certain and future studies will be necessary to verify it, this interpretation could be linked in particular to the changes observed in the variable of curricular greening. The pattern is observed in those students who attend eco-schools, which are systematic, stable over time and where teachers are committed to environmental education. In this context, it is plausible to hypothesise that the changes observed are of an adaptive nature, promoting a student profile that would be in line with the proactive pessimism proposed by Ojala (2022).

However, it should be noted that the presence of high levels of Worry (EIL very strong), accompanied by an increase in the mean scores of Powerlessness and Fear, and a decrease in Hope and Optimism, could be due to the perception of CC as an overwhelming phenomenon, potentially turning the influence of the educational system to negative. Although future studies are necessary to verify it, this interpretation seems to be more closely related to the influence of educational grade, mainly due to its effect on the increase in Powerlessness and decrease of Hope and Optimism, which are closely related to the perceived inability to address or overcome the problem (Pihkala 2022). Related to CC, Gunderson's (2022) and Williams and Jaftha (2020) studies indicate that feelings of Powerlessness are negatively correlated with decision-making and actions to combat and mitigate CC. These results would be in line with Jones and Davison (2021) findings on how educational experiences can promote maladaptive responses of paralysis and inaction in students towards the occurrence of CC.

The European Commission's recent report on the social perception of CC in European societies shows that out of 26,358 respondents from different age groups (15–24, 25–39, 40–54 and over-55), only the 15–24 age group identified CC as the most serious global problem. The report also notes that 'the longer a respondent remained in education, the more likely they are to think this [CC] is a very serious problem' (p. 25). However, Dechezleprêtre et al. (2022), in their demographic study of over 40,000 people from 20 countries, found no significant differences in the propensity to support climate policies based on age. The only

exceptions were Australia, France and the United States, where younger people were more likely to support these policies. These results are consistent with Heimlich et al. (2013) findings that pro-environmental behaviour does not show spontaneous or progressive changes with age. Future studies are essential to determine whether similar trends are observed, and qualitative data should also be collected to provide a more precise interpretation of the results obtained.

The role of information access barriers and the emotional footprint

The inferential analyses carried out for the sources of information block reveal significant differences in the emotional experience of the students in terms of the frequency of use (i.e. lightly, moderately, and widely) reported by the students for the different media studied, such as social, traditional, or specialised media.

Overall, the results show that the more frequently students reported using sources, regardless of their type, the higher the average scores they obtained for the two emotional dimensions studied, as well as for all the individual emotions. The sample's generalised pattern of behaviour is in line with the existing literature of emotional psychology, as it is suggested that the events or objects that can evoke an emotional process are only those that the subject considers relevant to their goals or survival, whether positively or negatively (Fernández-Abascal 2020). This phenomenon has been observed not only in relation to CC (Ojala 2012, 2022), but also in relation to survival-threatening issues such as COVID-19 (Huang and Yang 2020), as well as in social movements such as Black Lives Matter (Ellefsen and Sandberg, 2022) and Social Justice (Aldás and Pinazo 2013). Thus, the results obtained suggest a statistically significant reciprocal feedback between the emotional intensity reported by the subject in relation to the CC and the proactivity and interest shown by the subject in seeking information on a topic he or she considers relevant (Anguiano et al. 2021; Basch, Yalamanchili, and Fera 2022).

Based on the type of information sources in the study, two distinct dominant trends can be identified when examining the changes in EIL produced by the feedback patterns:

(1) Traditional media and specialised sources shows an 'initial stabilisation and final leap' pattern of changes in EIL. It is characterised by an increase of one level (strong or very strong) in the EIL of students who report using one of these information sources extensively, as opposed to those who consulted them lightly or moderately.

Several authors highlight that adolescents do not usually consult traditional media and specialised sources as frequently as they do with news sources related to new technologies; this may indicate a greater presence and predisposition for the latter sources (García, Tur-Viñes, and Pastor 2018; Teso, Morales-Corral, and Gaitán-Moya 2021). This context allows us to propose two related and feedback hypotheses to explain the variation in EIL obtained, in combination with the results obtained: (A) It is necessary for students to actively participate and intentionally use traditional media and specialised sources to bring about significant changes in their emotions; (B) students who use these media more frequently tend to exhibit

a higher interest (positive or negative) in CC, which makes them predictors of more intense emotional responses, as mentioned above.

Thus, in this study, the intensity of positive (Hope and Optimism) and negative (Anger, Sadness and Worry) emotional experiences towards CC is influenced by traditional media and specialised sources in a reciprocal and feedback system. In particular, it is possible to observe the link between the widespread use of these media and higher levels of EIL for emotions that the literature links to potential basic adaptive functions (Fernández-Abascal 2020). Anger, Sadness, and Worry are related to the promotion of behaviours such as: (A) Motivation and predisposition to develop plans for self-defence and the removal of obstacles that prevent the achievement of relevant goals – Anger – (Domínguez 2020). (B) Introspection and constructive analysis, allowing aspects of the situation-problem to be seen that previously could have been overlooked or that the subject would never have noticed – Sadness – (Domínguez 2020). (C) Generation of protective and preventive response patterns against the consequences that the triggering phenomenon could have – Worry – (Massoni 2014; Sweeny and Dooley 2018). However, for this to be possible, individuals need to perceive a degree of control over the outcome of the situation. Otherwise, maladaptive responses may be triggered, such as becoming shocked or paralysed (Massoni 2014; Sweeny and Dooley 2018). In this scenario, the positive emotions of Hope and Optimism can help to attenuate the most harmful psychological effects derived from coping with aversive situations, also increasing the subject's motivation to persevere and strive to achieve specific goals, allowing them to enjoy objectively unrewarding activities (Domínguez 2020).

(2) The 'staggered changes' pattern observed in EIL, particularly through the use of social networks, is characterised by gradual and continuous increments in EIL (ranging from very low to very high) as the frequency of use (light, moderate or high) of these information media increases. This model is postulated to be the most influential among the observed patterns in the study, as it can lead to an increase of up to two EIL levels in students.

In this case, the literature suggests that social networks, both physical (friends and family) and online (TikTok, YouTube, Twitter, among others), are one of the most commonly consulted means of communication among students, for both recreational and informative purposes. This situation allows us to hypothesise why these types of information sources are associated with a greater impact on EIL in the sample: they are the most accessible and frequently consulted media among this group, and students are more likely to resort to them to obtain information on topics they consider relevant (Anguiano et al. 2021; Basch, Yalamanchili, and Fera 2022; Moral, Fernández, and Ayuso 2021). It is important to consider the possible influence of search algorithms on the appearance of this pattern. Social networks often hide themes and searches that are not frequently performed or engaged, and show more of the information that we interact with (Fernandes 2022; Mao and Akyol 2020).

This 'step changes' method for social networks indicates notable differences in the EIL of negative emotions such as Worry, Powerlessness, Sadness and Anger.

However, exposure frequency on social networks does not produce significant alterations in the EIL of the pleasing emotions (Hope and Optimism), as seen in traditional media and specialised sources. The changes detected in negative emotions demonstrate a pattern where a minor use of social networks yields a very low EIL, a low EIL in moderate use, and a significantly high EIL in intensive use, except for Worry, which follows the same pattern, but with a higher EIL compared to Powerlessness, Sadness and Anger.

These findings, together with the tendency of adolescents to use social networks routinely, lead us to postulate three interrelated and interdependent hypotheses that may explain the differences in EIL among secondary school students: (A) Social networks do not pose any hindrance to students who use them. Thus, students who slightly rely on them to learn about CC are possibly disinterested in the topic, which correlates with reduced emotion intensity on average, as seen in the EIL attained by this group. (B) Students who moderately use social networks demonstrate an interest in the area but may not see it as relevant to their personal objectives. Thus, they attain an EIL matching the general population sample. (C) Very frequent social network users are the ones displaying significant interest in CC, hence resulting in average high emotional intensity scores (strong or very strong) as seen in their EIL. These findings highlight the significance of information sources, particularly Social networks, in promoting emotions and affective engagement with CC in young adolescents. However, studies by Kondamudi et al. (2023) and Azzimonti and Fernandes (2023) point to the prevalence of fake news or disinformation in these types of information sources, despite the efforts of networks such as X (previously Twitter) or TikTok to eradicate it. This issue also affects CC communication, as noted by studies conducted by Gounaridis and Newell (2024), Güneri and Taddei (2023), and Kathie, Hywel, and Saffron (2020). This points to an evolving area in which environmental education should be involved and mainstreamed, encouraging the promotion of reliable and truthful information in these online and collective media.

Climate action is related to a predominantly negative/unpleasant emotional footprint

Regarding the inferential analyses of the climate action block, students' emotional experiences exhibit significant differences concerning reported participation in climate movements, climate strikes, voluntary activities in environmental groups and school.

As observed in the sources of information block, the general results highlight that students who reported participating in these activities have averaged higher scores in emotional experience compared to those who did not. In this case, the changes are only reflected in the NE dimension and its respective components. PE in the study were affected only by participation in schools' voluntary activities and not by the other activities studied.

In detail, we observe significant differences in the average scores of students who participate in climate movements, environmental groups' activities and school voluntary activities. The results indicate that participation in such pro-environmental activities is related to higher negative emotions, as well as

qualitative changes in EIL between groups. Participating in climate strikes is the only exception, as it only affects negative emotions associated with high arousal and, consequently, there is a greater tendency towards combative behaviour and the search for the elimination of the perceived threat. It is worth mentioning Anger and Indignation, as these emotions are generally triggered by the perception that the aversive situation is caused by an entity or subject against which there is a means of coping to eradicate it (Domínguez 2020; Pihkala 2022; Poma 2019).

These results reiterate the existence of a mutual feedback cycle between the emotional intensity of the subject concerning the CC and the proactivity and interest demonstrated in addressing a situation relevant to their personal goals and objectives (Fernández-Abascal 2020). This is consistent with Ellefsen and Sandberg (2022) research on the emotional aspect of political action, and participation in social justice movements and activism (Aldás and Pinazo 2013). However, in contrast to what was observed in the information sources block, this pattern of participation in actions linked to the CC block has a predominant and well-established association with negative emotions.

These findings are consistent with several previous studies (Brügger et al. 2020; Hyry 2019; Nairn 2019; Ojala 2012; Pihkala 2022; Poma 2019), as well as the literature on environmental and emotional psychology. It is negative emotions that have the greatest potential to promote pro-environmental decision-making and even proactive participation in the fight against CC (Nairn 2019; Neas 2023). This is because they require the mobilisation of significant cognitive and behavioural resources to be used in the creation and development of plans to resolve or alleviate the situation (Fernández-Abascal 2020). However, this contradicts to some extent the results obtained by Ratinen and Uusiautti (2020), Smith and Leiserowitz (2014), Ojala (2012, 2022) and Hickman et al. (2021), who found strong associations between participation in the fight against CC and positive emotional experiences such as Hope, Optimism, joy and happiness. In any case, an open question is whether emotions are intensified through pro-climatic action or whether this action is motivated by a more intense emotional experience. Therefore, it is considered necessary to further explore the role of both emotional categories in climate action and to have qualitative information that allows a more precise interpretation of the results obtained.

Limitations and further research

Among the limitations of the study, it is worth mentioning that the sample size, although relatively large and representative of the south of Spain, is still limited to this region. Additionally, we acknowledge the intrinsic connection between emotional processes, evaluative mental frameworks, and cultural constructions of the subjects in relation to specific phenomena. Therefore, caution should be exercised in generalizing our conclusions to other territorial contexts, particularly regarding secondary or social emotions.

The complexity of the emotional processes makes it difficult to generalise the partial hypotheses of the work to a certain extent, as we only have quantitative information. National and international replication studies are needed to verify the partial hypotheses presented and to contrast them with qualitative research, which

allows us to delve deeper into the evaluative processes underlying the emotional responses expressed by the students through open-ended questions or interviews. The paper presents a promising area for further research. To enhance the validity and reliability of the findings and conclusions, cross-sectional and/or longitudinal studies must be conducted.

Additionally, achieving a more proportional distribution of positive and negative emotions, including neutral emotions such as indifference, could establish a better understanding of the emotional climate in students' identities. Similar research in countries internationally recognised as pioneers in climate policy, education and/or activism, as opposed to others with less institutional and cultural tradition, could reveal new avenues for research.

Conclusions

The study's overall results on the emotional impact of climate change (CC) do not show a clear predominance between the different positive and negative emotions explored. This aligns with previous studies and surveys conducted on young people across the globe: CC is a predictor of a wide range of emotions with diverse emotional Valence characteristics (Martin et al. 2023; Ojala 2022; Pihkala 2022; Ramadan et al. 2023). However, emotions are complex and multidimensional processes with a strong Appraisal component that determines the intensity and type of resulting emotion. Therefore, it is necessary to investigate the potential impact of other factors or variables that contribute to emotional Valence dominance in the sample.

Formal education (educational grade and curricular greening) amplify negative emotions in students regarding CC. This pattern does not necessarily indicate a positive or negative effect of formal education. However, based on the study results and sample context, it is hypothesized that: (A) curricular greening effect on students seems to be positive, as it could be linked to a more realistic perception of CC, which decreases maladaptive positive emotions that could potentially suppress the need to act or readjust plans. (B) educational grade effect is ambiguous; however, it appears to be potentially negative as it increases Powerlessness, one of the few negative emotions that negatively correlate with decision-making and action.

Results on Sources of information indicate that a higher frequency of consultation in any of the three typologies explored leads to higher mean scores for emotions, regardless of their Valence. This is consistent with the literature on emotions, which suggests that the intensity of the elicited emotion is greatly influenced by the relevance that the subject gives to the object (Fernández-Abascal 2020). Traditional media and specialised sources present barriers to accessing information about CC, requiring an active and deliberate search to generate significant changes in Emotional Intensity Levels (EIL). However, social networks do not present any access barrier and also have a stronger relationship with changes in the EIL of the sample. These results demonstrate the broad potential of media in the emotional Appraisal of CC in young people, particularly social networks. Environmental education should aim to integrate with new media, particularly online, to emotionally engage with current generations.

Participation in climate action results indicate a mutual feedback pattern between the subjects' EIL concerning CC and their proactivity and interest in addressing a situation relevant to their personal goals and objectives, similar to the trend observed in Sources of information. However, inferential tests indicate a clear emotional Valence predominance in these divergences, with only negative emotions being significantly higher in students who do participate in climate mobilisation. The only exception is school voluntary activities, where differences are present in all the emotions studied. These results are consistent with trends observed in numerous studies (Pihkala 2022; Poma 2019) and somewhat contradicts strong associations between pro-climatic action and positive emotional experiences, such as Hope and Optimism, found in others (Hickman et al. 2021; Ojala 2022). This study highlights the potential for negative emotions to drive climate action, consistent with existing literature on the empowering effect of such emotions in generating plans and participation in actions to address the problem that elicits them (Fernández-Abascal 2020; Pihkala 2022).

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