

Article

Climate Change, Education, Training, and Perception of Pre-Service Teachers

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Abstract: This study aims to analyze the level of teacher training and education on climate change received by future Social Science teachers in Primary Education. Based on a questionnaire completed by 1224 pre-service teachers from five Spanish universities and one Colombian university, the main results indicate that the majority received training on this phenomenon during their school years (78.3%), though the percentage nearly halves in higher education (44.0%). In addition, future Social Science teachers have a moderate level of preparation—half of the participants selected “3” on a Likert scale (1 to 5), accounting for 54.2% of responses. For this reason, it is necessary to expand climate change education in higher education in order to equip teachers for addressing future environmental issues in the classroom. Education represents one of the most important factors in adapting to climate change, helping present and future societies build resilience to climate change scenarios.

Keywords: training; pre-service teachers; climate change; primary education



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1. Introduction

Climate change, as explained by various authors (Keller et al. 2022; Serrano-Notivoli et al. 2024) and the Intergovernmental Panel on Climate Change (IPCC 2022), is a critical phenomenon that global society must address due to its implications for various regions and the need for adaptation and resilience (Cutillas et al. 2023; Olcina 2024). Recently, the largest public opinion survey on climate change, conducted by the United Nations (UN 2024) and titled “The People’s Climate Vote 2024”, gathered responses from 73,000 people across 77 countries. The results indicate that 80% of the global population wants their governments to take more decisive action to address the climate crisis. At the global level, 56% of respondents reported thinking about climate change regularly—daily or weekly—including 63% in developing countries.

Regarding the educational field, climate change is a necessary topic for 21st-century education (Antronico et al. 2023; Kim and Jin 2024; Morote and Moreno-Vera 2021; Rodríguez-Pizzinato and Morote 2024; Rouhiainen and Haanpää 2024; UNESCO 2021) due to the

effects currently observed and anticipated in the coming decades (Pastor and Khodayar 2023). The trigger for this research is the need to understand the social representations of future Primary Education teachers to teach about this phenomenon. Climate change represents a challenge humanity must face today, shaping societal development due to its effects (IPCC 2022). The research focus on social representations is justified by their influence on the construction of knowledge (Moscovici et al. 1969), which Hardy and Jackson (1997) later indicated depends on the acceptance and retrieval of information to form theories that make sense of the interpretation of reality and influence behavior.

Climate change education faces significant challenges, as highlighted in the UNESCO (2021) report (“Teachers Have Their Say: Motivation, Skills, and Opportunities to Teach Education for Sustainable Development and Global Citizenship”). One of the primary issues identified is the lack of adequate teacher training in climate change and sustainability topics. Many educators feel unprepared to teach these subjects effectively, limiting students’ understanding of the scientific, social, and economic dimensions of climate change. Additionally, while teachers recognize the importance of integrating climate change education, they often lack the necessary resources and institutional support. Constraints imposed by curricula, pressures of standardized testing, and insufficient professional development opportunities further hinder their ability to incorporate climate-related topics into their lessons. Moreover, variations in national policies and educational frameworks result in inconsistencies in how climate change is taught across different regions. This report also emphasizes the need for interdisciplinary approaches and active student engagement to foster critical thinking and problem-solving skills. Addressing these challenges requires comprehensive teacher training programs, updated curricula, and a stronger institutional commitment to sustainability education.

Notable works include studies conducted in North America (Kim and Jin 2024; Mitchell 2023), South America (Cruz and Páramo 2023; De Melo et al. 2024; Quintero and Solano 2024; Ruiz-Chila et al. 2023), Europe (Antronico et al. 2023; Morote and Olcina 2021; Olcina et al. 2023; Rissanen et al. 2024), Asia and Oceania (Rouhiainen and Haanpää 2024; Satyawati and Baskara 2023), and Africa (Ofori et al. 2023). Regarding the study of this phenomenon in schools, some authors have analyzed students’ understanding of climate change (Leal et al. 2023; Morote and Hernández 2024; Sánchez-Almodovar et al. 2023). Other studies have explored teaching climate change in schools and examined teachers’ hesitation to teach these topics (Rodríguez-Pizzinato and Morote 2024; White et al. 2022). Some research has proposed classroom activities on climate change and its effects (e.g., natural hazards) (Olcina et al. 2022).

Recently, the considerable increase in these contributions at the international level highlights the interest in teaching this topic, considering the relevance of climate change-related challenges in modern society. It is also important to note the support from key policies and organizations that promote its study and implementation, such as the United Nations Sustainable Development Goals (SDGs) (UN 2015). Additionally, the publication of the IPCC’s Fifth Assessment Report (IPCC 2014) emphasized the importance of teaching climate change through educational programs. For example, Spain’s LOMLOE (2020) (Ministry of the Presidency, Justice, and Relations with the Courts 2020) gives more attention and encouragement to teaching sustainability and climate change, making this topic present in different areas of both Social and Natural Sciences.

The objective of this research is to analyze, based on the social perceptions of pre-service Primary Education teachers, their perceptions of climate change. The Specific Objectives (S.O.) are to analyze the following: (1) the training received during their primary and secondary school years; (2) their assessment of whether their university training prepared them to teach this phenomenon; (3) the representations of climate change’s effects

on daily life and the gaps between perceived realities and constructed views; and (4) the role attributed to humans in global warming.

Hypothesis 1 predicted that future teachers would report a medium or high percentage of positive responses regarding the training received during their school years, with a lower percentage for university education, in line with other previously published studies (Morote et al. 2023). For example, these authors, in relation to pre-service teachers, reported a moderate to high percentage of positive responses regarding the training received during their school years, although this percentage was lower for university-level training.

Hypothesis 2 anticipates a predominant identification of human activity as a cause and a perception of climate change effects in daily life. Following studies published in the last decade, human activity was predominantly identified as a cause (Escoz-Roldán et al. 2020), along with a series of perceived climate change effects in daily life (Baldwin et al. 2022).

Finally, regarding Hypothesis 3, it is suggested that participating teachers view humans as key drivers of global warming, as indicated by previous studies in other countries (Pickering et al. 2020; Velázquez et al. 2021).

2. Materials and Methods

2.1. Design Research

This research is characterized as a correlational, non-experimental explanatory study (Pérez-Castaños and García-Santamaría 2023), based on the use of a mixed questionnaire for data collection, which is common in studies within the Social Science education field (Gómez-Carrasco et al. 2022; Moreno-Vera and Martínez-Leguizamo 2022). In terms of the temporal aspect, the design is a cross-sectional design, capturing data from specific points in time, as the information was collected during specific periods across the 2018–2019 and 2022–2023 academic years, with data grouped by teacher training groups from each university.

2.2. Context and Participants

The selection of participants was carried out through non-probabilistic convenience sampling based on students available at participating universities (Wellington 2015). This study included pre-service Primary Education teachers enrolled in Social Science courses at five Spanish universities and one Colombian university (Figure 1 and Table 1). The total number of students enrolled in these courses is 1746. To obtain a representative sample, considering the total number of enrolled students ($n = 1746$), with a 99% confidence level and a 5% margin of error, it was deemed necessary to obtain a minimum of 483 participants. In the end, the total number of pre-service teachers who participated was 1224, thus achieving a highly representative sample for the study (Table 1).

Table 1. Pre-service primary education teachers who participated in the research.

	Enrolled Students (<i>n</i>)	Participating Students (<i>n</i>)	Average Age	Sex	
				Man	Women
University of Alicante (UA)	345	232	21.0	27.6% (<i>n</i> = 64)	72.4% (<i>n</i> = 168)
University of Castilla-La Mancha (UCLM)	297	154	20.4	33.8% (<i>n</i> = 52)	66.2% (<i>n</i> = 102)
University of Murcia (UMU)	120	89	20.3	16.8% (<i>n</i> = 15)	83.1% (<i>n</i> = 74)
University of Valencia (UV)	654	549	21.7	12.2% (<i>n</i> = 100)	81.8% (<i>n</i> = 449)

Table 1. Cont.

	Enrolled Students (<i>n</i>)	Participating Students (<i>n</i>)	Average Age	Sex	
				Man	Women
University of Valladolid (UVA)	140	89	19.8	39.3% (<i>n</i> = 35)	60.7% (<i>n</i> = 54)
University Distrital of Francisco José de Caldas (UD)	190	111	21.8	73.9% (<i>n</i> = 82)	26.1% (<i>n</i> = 29)
Total	1746	1224	21.2	28.4% (<i>n</i> = 348)	71.6% (<i>n</i> = 876)

Source: results of the questionnaire. Own elaboration.

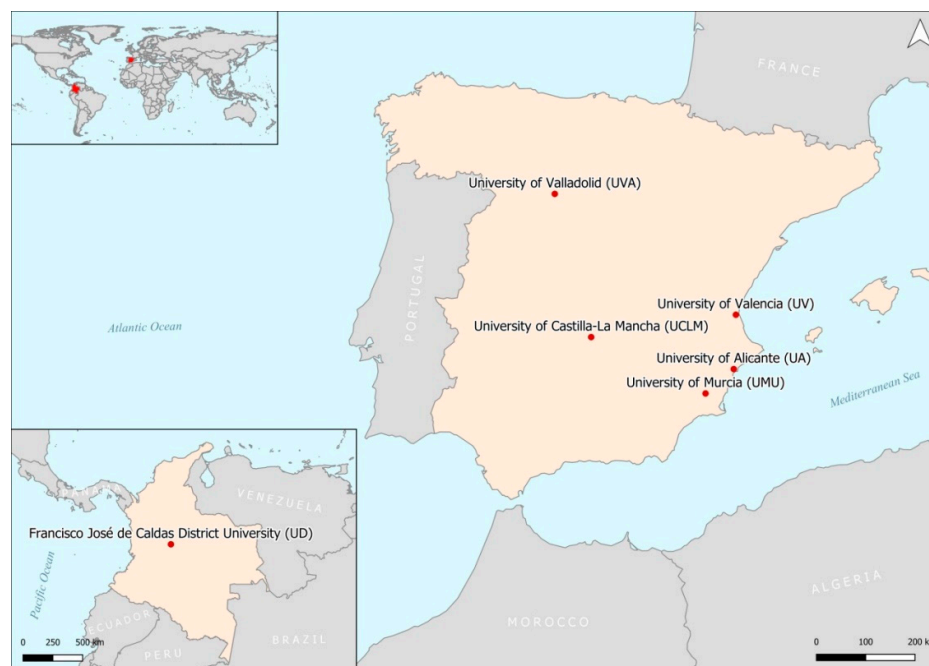


Figure 1. Universities that participated in the study. Source: own elaboration.

The average age of the sample is 21.2 years. From a gender perspective, females constitute the majority at 71.6% (*n* = 876) (Table 1).

2.3. Research Instrument

The data collection process was carried out through the implementation of a questionnaire previously used in research (Morote and Moreno-Vera 2023). This mixed questionnaire (quantitative and qualitative) contains 21 items distributed across different sections: (1) socio-educational characteristics; (2) school training on climate change; (3) the importance of media; (4) teachers' perceptions of climate change; and (5) teacher training on climate change. Based on the study's objectives, items from Section 2 (Item 3), Section 4 (Items 10–13), and Section 5 (Items 15 and 17) were analyzed, using different scales (standardized Likert-type scale or dichotomous scale, depending on the specific item) and closed responses (Appendix A Table A1).

Regarding the research instrument, to assess construct validity, a statistical analysis of the ordinal variables was performed. It was verified that these variables met an acceptable standard deviation (SD) of $0 < 1$. Once this check was completed, the construct was subjected to the Kaiser-Meyer-Olkin (KMO) validity test to assess whether the factor analysis of the instrument could be considered appropriate. This test resulted in a positive value of 0.491, deemed acceptable in factorial reliability studies (Pérez-Gil et al. 2000). Moreover, since it is a mixed questionnaire, the Friedman Chi-Square test (Friedman's

χ^2) was performed, yielding a p -value of 0.001, indicating variable dependence with no discrepancies (Satorra and Bentler 2010; Sharpe 2015). This strengthens the reliability and validity of the research, as demonstrated in similar educational research studies (Creswell 2014), especially in Social Science education (Moreno-Vera and Martínez-Leguizamo 2022).

2.4. Procedure

The questionnaire was administered in an intermediate session with a response time of 20 min during the first semester of the academic years 2018–2019 to 2022–2023 in Social Science courses. Student anonymity was maintained through a numerical participant list, with written assurance of confidential data handling (Organic Law 3/2018).

The study was conducted in accordance with the guidelines of the Helsinki Declaration (World Medical Association), ensuring ethical commitment, respect for human dignity, privacy, and protection of personal data during the survey. Privacy standards were followed, in compliance with the Organic Law 3/2018 on data protection, anonymity, and informed consent, and informed consent (Hirsch and Navia 2018). The study's objectives and its relevance to future teacher training were clearly communicated.

2.5. Data Analysis

Regarding the data analysis procedure, SPSS (v.28) was used to conduct a statistical-inferential analysis (non-parametric tests) of frequencies and percentages. The Chi-Square test (χ^2) was initially applied when it was necessary to correlate nominal variables (items 3, 10, 11, 12, 13, and 15) across the different participant groups from each university, with the aim of detecting linear relationships between these items. Moreover, the Kruskal–Wallis H test was then applied to correlate ordinal variables (Item 17) among the teacher groups in accordance with the procedures of other studies (Morote and Moreno-Vera 2023).

3. Results

3.1. Teacher Training and Professional Development

The data obtained from the first analyzed item (Item 3: “During your school years, did you receive any type of training on climate change?”) reveal that the majority of participants overall (78.3%; $n = 959$) did receive training on these topics (Figure 2). Notably, students from the universities of Valladolid (85.4%; $n = 76$), Valencia (84.3%; $n = 463$), and Castilla-La Mancha (81.8%; $n = 126$) reported receiving more extensive training. In particular, these participants, who are future Primary Education teachers, demonstrated higher levels of training. Lower percentages were recorded at Distrital University (64.0%; $n = 71$) and the University of Murcia (67.4%; $n = 60$).

To determine whether there is a statistically significant association between the climate change training received during school and the teacher group (based on their university), a chi-square test was conducted. The results indicate that the association between these two variables is significant (Pearson's Chi-Square = 79.099; $p = 0.001$). Thus, the findings suggest that the variables are dependent on each other. In other words, the climate change training received during school is influenced by the teacher group.

Regarding climate change training received during university studies (Item 15), the results differ from the previous ones. In this case, more than half of the participants reported not having received training (56.0%; $n = 685$). For instance, the University of Castilla-La Mancha stands out with figures exceeding 70.0%. On the other end, the teacher group from the University of Valencia reported lower levels (50.3%). These findings highlight the limited attention given to this topic during university education, in contrast to earlier educational stages.

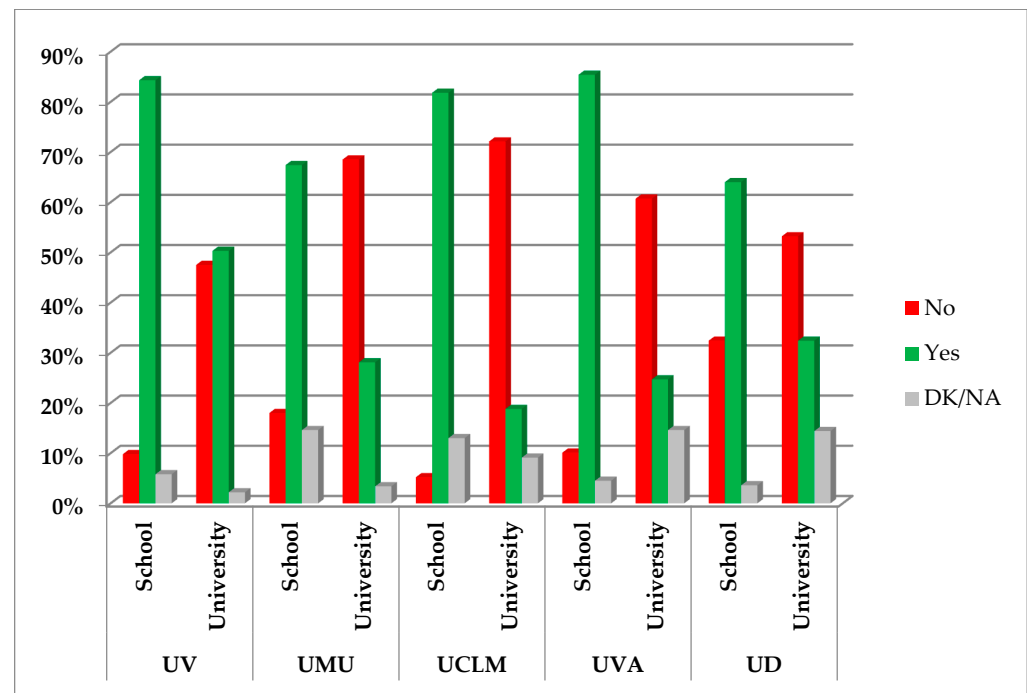


Figure 2. School (Item 3) and university (Item 15) training received on climate change. Source: results of the questionnaire. Own elaboration.

To determine whether there is a statistically significant association between university-level training and the teacher group (based on their university), a chi-square test was conducted again. The results indicate that the association between these two variables is significant (Pearson's Chi-Square = 110.036; $p = 0.001$).

Climate change is present in the majority of the participants' school memories. However, some irregularities are noticeable, possibly related to the territorial development of curricula. For instance, 85.4% of participants from the University of Valladolid recall receiving training on this topic, compared to 67.4% at the University of Murcia, a figure close to that of the University of Colombia (64.0%). The most significant difference is observed between the results from the universities of Valencia and Alicante, even though both share the same curriculum.

Discrepancies are even more pronounced in university-level training, where another circumstance stands out: the limited inclusion of climate change as a topic in teacher education. At the University of Valencia, this content is present in 50.3% of cases. In all other universities, including the University of Colombia, the figure is lower.

Regarding teacher preparation to teach this phenomenon in school classrooms (Item 17), it is notable that half of the participants selected "3" (moderate preparation) on a Likert scale from 1 to 5, accounting for 54.2% of responses ($n = 663$). When analyzing these data by teacher groups, those who feel most prepared are from the University of Alicante (the combined values of "4" and "5" total 39.7%) and the University of Valladolid (the combined values of "4" and "5" total 31.5%) (Table 2). Interestingly, the latter group (UVA) is among those who reported receiving the least university-level training but, conversely, includes a significant percentage of participants who feel adequately prepared to teach this basic knowledge.

To assess whether there are statistically significant differences in teacher preparation by group, the Kruskal–Wallis H test was conducted. This test shows significance (Kruskal–Wallis H = 43.252; $p = 0.001$). In other words, the preparation of pre-service teachers to teach climate change content is influenced by the university.

Table 2. “Are you trained to teach these topics?” (Item 17).

		1	2	3	4	5	Total
UA	<i>n</i>	12	30	98	60	32	232
	%	5.2%	12.9%	42.2%	25.9%	13.8%	100.0%
UV	<i>n</i>	40	58	353	63	35	549
	%	7.3%	10.6%	64.3%	11.5%	6.4%	100.0%
UMU	<i>n</i>	3	24	38	20	4	89
	%	3.4%	27.0%	42.7%	22.5%	4.5%	100.0%
UCLM	<i>n</i>	5	31	76	29	13	154
	%	3.2%	20.1%	49.4%	18.8%	8.4%	100.0%
UVA	<i>n</i>	1	13	47	24	4	89
	%	1.1%	14.6%	52.8%	27.0%	4.5%	100.0%
UD	<i>n</i>	12	25	51	21	2	111
	%	10.8%	22.5%	45.9%	18.9%	1.8%	100.0%
Total	<i>n</i>	73	181	663	217	90	1224
	%	6.0%	14.8%	54.2%	17.7%	7.4%	100.0%

Source: results of the questionnaire. Note: Likert scale responses (1 to 5). Own elaboration.

The data obtained confirm that more than half of the participants assign a mid-level score to their assessment of university-level training. These findings suggest that approximately half of the participants are aware that their training on climate change is not enough. The combined scores of “4” and “5” on the Likert scale (25.1%) clearly exceed those who scored “1” and “2” (20.8%). Once again, it is important to note that the results reflect evaluations of cognitive representations rather than tests measuring specific knowledge. The analysis also indicates significant training differences based on the university attended.

3.2. Causes, Consequences, and Perceived Effects of Climate Change

The causes, consequences, and perceived effects of climate change identified by pre-service Primary Education teachers will be analyzed below. With regard to the causes, two stand out prominently: pollution (46.9%; $n = 574$) and the lack of human awareness (32.1%; $n = 393$) (Figure 3). In both cases, the causes are human-induced (together, these two values account for 79.0%). When analyzing these data by university, it is evident that certain groups prioritize some causes over others, influenced by the geographical context of each university (Figure 3). In the case of Colombia, factors such as the exploitation of its rich natural resources, heavily utilized for the export of raw materials to the rest of the world, may contribute significantly.

To assess whether there is a statistically significant association between the identified causes and the teacher group, a chi-square test was conducted. The results indicate that the association between these two variables is significant (Pearson’s Chi-Square = 288.681; $p = 0.001$).

Regarding the consequences (Item 11), analyzing the data holistically reveals two primary aspects: (1) the depletion of natural resources (25.0%; $n = 306$) and (2) the rise in temperature (19.2%; $n = 235$). When examining the data separately, for example, the group from the University of Valladolid identified the rise in temperature with a response rate of 30.3%, while the group from Colombia emphasized the increase in natural risks at 19.8%.

To assess whether there is a statistically significant association between the identified consequences and the teacher group, a chi-square test was conducted. The results indicate that the association between these two variables is significant (Pearson’s Chi-Square = 104.334; $p = 0.001$), demonstrating that the variables are interdependent.

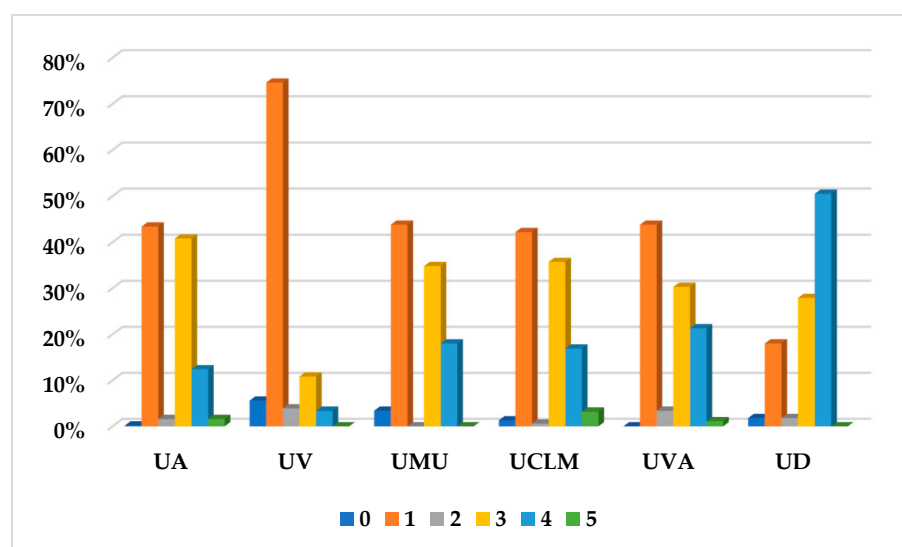


Figure 3. “In your opinion, what are the main causes of climate change?” (Item 10). Source: results of the questionnaire. Own elaboration. Coding of Responses for Item 10: “Do not know /No answer” (0); “Pollution” (1); “Deforestation” (2); “Lack of human awareness” (3); “Overexploitation of natural resources” (4); “Natural causes” (5).

Thirdly, regarding the effects perceived by the participants, the data overall indicate that the most recognized effect is the rise in temperature (53.3%; $n = 653$) (Figure 4). When analyzing these data by institution, pre-service teachers from the University of Valencia perceive this effect most prominently (69.4%; $n = 381$). Additionally, it should be highlighted that the groups from the University of Alicante and Colombia identified the effect of “socio-economic conflicts” with 48.3% and 26.1%, respectively. The chi-square test results suggest that the association between these variables is significant (Pearson’s Chi-Square = 454.414; $p = 0.001$).

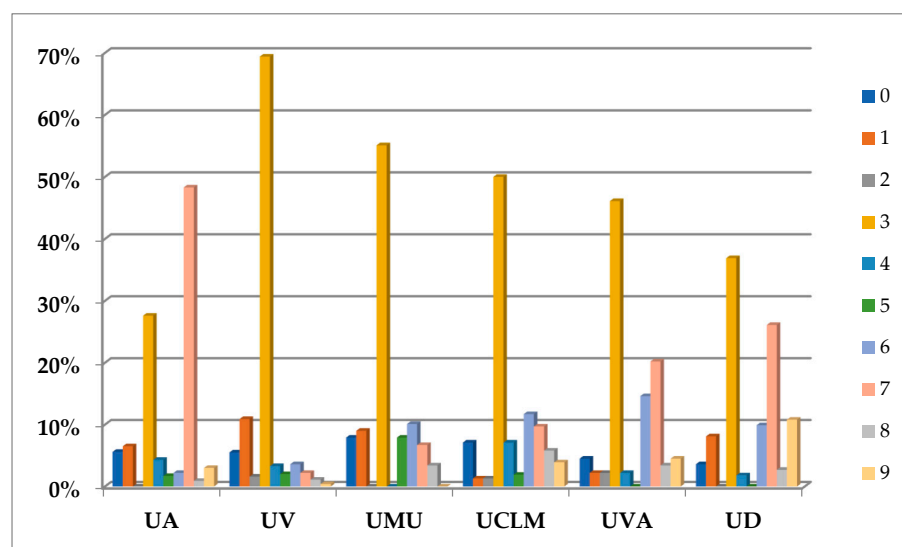


Figure 4. Perceived effects (Item 12) identified by pre-service Primary Education teachers. Source: results of the questionnaire. Own elaboration. Coding of Responses for Item 12: Do not know /No answer” (0); “Increase in natural hazards” (1); “Increase in invasive species” (2); “Increase in temperature” (3); “Melting and rise in sea level” (4); “Extinction of species” (5); “Depletion of natural resources” (6); “Socio-economic conflicts” (7); “Destruction of the ozone layer” (8); “Increase in diseases” (9).

3.3. Climate Change According to Pre-Service Teachers

In this section, the opinions of pre-service teachers regarding climate change (Item 13) are analyzed (Figure 5). The opinion that “climate change has always existed, but human activity is accelerating it” stands out, with 75.8% ($n = 928$). Additionally, the responses grouped under the statement “climate change is caused solely by human activity (anthropogenic greenhouse effect)” account for 20.4% ($n = 250$).

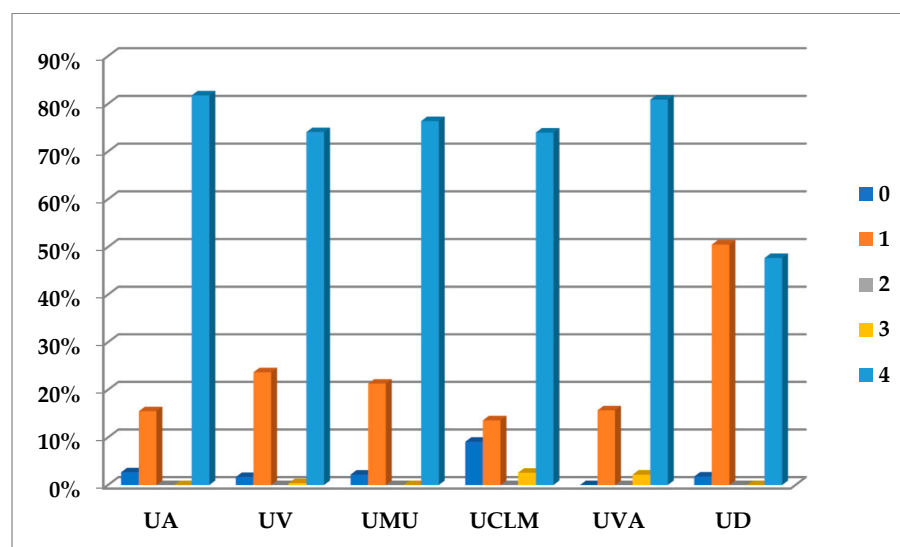


Figure 5. Opinion on climate change according to pre-service Primary Education teachers (Item 13). Source: results of the questionnaire. Own elaboration. Coding of Responses for Item 13: “Do not know/No answer” (0); “Climate change is caused only by human action (anthropogenic greenhouse effect)” (1); “I do not believe in climate change” (2); “Climate change has always existed, but humans are not accelerating it” (3); “Climate change has always existed, but humans are accelerating it” (4).

It is therefore evident that human activity is acknowledged as a factor influencing global warming according to the participants’ responses. Interestingly, for the Colombian group, these two opinions display similar percentages. This demonstrates that Spanish pre-service teachers believe that climate has evolved throughout history and that human actions are accelerating this process. Finally, it should be noted that no responses denying the existence of global warming were recorded.

In order to evaluate whether there is a statistically significant association between opinions on climate change and the group of pre-service teachers, the chi-square test was conducted. The test results indicate that the association between these two variables is significant (Pearson’s Chi-Square = 138.930; $p = 0.001$).

4. Discussion

This research has advanced the understanding of the training and education received by, as well as the perception of future Primary Education teachers in Spain and Colombia regarding climate change. The first hypothesis proposed that a “medium or high percentage of positive responses from future teachers concerning the training received during their school years would be expected, although showing a lower percentage regarding their university education”. This hypothesis is confirmed. The results indicate that 78.3% of participants reported receiving training on climate change during their school years. Moreover, statistical analysis revealed an association between different groups of teachers based on their universities. For example, higher levels of training were reported at the University of Valladolid (85.4%), Valencia (84.3%), and Castilla-La Mancha (81.8%) compared to other institutions.

Other studies analyzing similar experiences from school years have shown lower training results. For example, in Eilam's (2022) study, only about half of Primary Education (54.0%) and Secondary Education students (55.0%) received specific training, while the percentage rose to 74.3% in Early Childhood Education. A similar pattern is observed in higher education, where 56.0% of future teachers reported not receiving training on climate change (Morote and Moreno-Vera 2023; Reid 2019).

Research suggests that pre-service teachers are often better informed about climate change during their school years than at the university level, due to the growing emphasis on environmental education in Primary and Secondary curricula. In recent years, many schools have integrated climate change topics into Science, Geography, and even Social Studies courses, ensuring that students are exposed to updated and relevant information from an early age (Ruiz-Chila et al. 2023). Additionally, interactive teaching methods, such as project-based learning and hands-on activities, enable younger students to better understand complex environmental issues (Olcina et al. 2022). In contrast, university curricula may not prioritize climate change unless students are enrolled in specific environmental science programs, or because university instructors themselves often lack training in climate change-related geography (Olcina et al. 2023). As a result, many university students lack the foundational knowledge provided during earlier stages of education and may view climate change as a topic outside their field of study. Moreover, younger students are more likely to engage with global climate movements, inspired by figures like Greta Thunberg, which further enhances their awareness compared to that of older peers.

Regarding self-perceived competence, 54.2% of participants reported a moderate level of competence in teaching this content (a score of '3' on a Likert scale). Statistical analysis also revealed significant differences among universities, with students from the University of Alicante and Valladolid perceiving themselves as the most competent.

Previous studies suggest that future teachers often lack confidence in teaching these topics, with data showing a "medium" level of competence. This lack of confidence is more pronounced in pre-service teachers from Primary Education (89.9%) and Secondary Education (73.8%), where climate change topics are more complex and require analysis from multiple perspectives (Leyschon 2014). This is a significant and concerning finding, as research conducted in Taiwan by Wang and Tsai (2022) has shown that teacher training aimed at educating students and mitigate their social vulnerability to natural disasters is critically important, given the annual toll of such phenomena.

The UNESCO (2021) report provides a comprehensive analysis of the role teachers play in fostering sustainable development and global citizenship through education. Drawing on global data, the report examines teachers' motivation, skills, and the resources available to integrate these topics into their teaching practices.

It highlights that many educators recognize the importance of addressing sustainability and citizenship education but face significant challenges, such as insufficient training, limited professional development opportunities, and inadequate institutional support. The report underscores the need for targeted investments in teacher preparation programs to enhance educators' skills and confidence in delivering interdisciplinary, future-focused curricula.

Our study aligns with the UNESCO (2021) report in identifying critical gaps in teacher training programs focused on education for sustainable development and climate change. Both highlight the pressing need to improve teacher preparation so they can effectively address global challenges. While our findings reveal that future Social Science teachers feel underprepared, particularly at the higher education level (with only 44.0% receiving training), UNESCO similarly underscores global challenges such as limited professional development opportunities and insufficient systemic support. The shared emphasis on fostering teacher confidence and competence highlights the importance of targeted invest-

ments in curricula and professional training programs. By adopting an interdisciplinary and up-to-date approach, as both studies advocate, teacher education can empower educators to promote sustainability and resilience among students, equipping them to navigate climate change challenges. Together, these insights reinforce the role of education in shaping environmentally responsible societies.

Regarding the second hypothesis, it proposed that “a predominant identification of causes linked to human activity, along with a perception of climate change effects in everyday life, would be observed”. This hypothesis is confirmed as well. Previous studies have reported similar findings, both in terms of the human origin of the phenomenon (Escoz-Roldán et al. 2020) and the perceived effects noted by students (Baldwin et al. 2022; Sánchez-Almodóvar et al. 2023).

The results of the causality analysis allow us to conclude that this representation is primarily associated with pollution and irresponsible human behavior. The causes identified in this study are twofold: pollution (46.9%) and a lack of environmental awareness among humans (32.1%). In both cases, the origins are human, with the combined percentage reaching 79.0%. Additionally, statistical analysis has shown an association between different teacher groups based on their university affiliation. For instance, at the University of Alicante, “pollution” is identified by 74.6% of respondents, while in the Colombian group, the most cited cause is “overexploitation of natural resources” (50.5%). Colombian society often perceives environmental issues more clearly than Spanish society due to its direct dependence on natural ecosystems. Colombia’s economy relies heavily on agriculture, mining, and biodiversity, making the impacts of deforestation, pollution, and climate change more evident in daily life (Rodríguez-Pizzinato and Morote 2024). Additionally, frequent environmental crises like floods, landslides, and deforestation in the Amazon raise public awareness. In contrast, Spain, while facing its own environmental challenges, has more urbanized lifestyles and developed infrastructure, which can obscure the immediacy of ecological problems (Olcina et al. 2023). Media focus, cultural ties to nature, and grassroots activism in Colombia also play a key role in shaping this awareness.

In northern Europe, Escoz-Roldán et al. (2020) found that 85.0% of their participants (undergraduate students) believed climate change is primarily caused by human actions. This percentage increases to 91.3% in the study by Sánchez-Almodóvar et al. (2023) in Spain. Similar findings have also been documented in the UK (Kurup et al. 2021), Mexico (Calixto 2018), and Asia (Chang and Pascua 2016).

Similarly, Jamelske et al. (2013) compared the opinions of Chinese and American university students on whether the primary causes of global warming are human or natural. Among Chinese students, 86.4% attributed the phenomenon to anthropogenic causes, while only 59.0% of American students did so. However, studies that report notably lower attribution to human causes also exist, such as Li and Liu (2021) in Taiwan, where 38.0% of university students identified human origins. Furthermore, Wu and Otsuka (2021) in Shanghai (China) highlighted that Secondary Education students often lack a complete understanding of and accurate conception of the phenomenon.

The perception that humans are the primary cause of climate change stems from comprehensive scientific research. Studies highlight how human activities, such as burning fossil fuels, deforestation, and industrial processes, release large amounts of greenhouse gases like carbon dioxide (CO₂) and methane into the atmosphere. This intensifies the natural greenhouse effect, leading to a rise in global temperatures. Additionally, climate models show that natural factors, such as volcanic activity or solar cycles, cannot fully explain the current accelerated warming (Serrano-Notivol et al. 2024). Reports from organizations such as the Intergovernmental Panel on Climate Change (IPCC 2022) emphasize the link

between human actions and climate change, shaping public opinion through education, media coverage, and observable environmental impacts.

Regarding the consequences, two stand out based on the number of responses: (1) depletion of natural resources (25.0%); and (2) temperature increases (19.2%). Statistical analysis, as with the previous results, revealed a significant association between teacher groups based on their university affiliation.

These findings can be compared to those of [Sánchez-Almodóvar et al. \(2023\)](#), where the most frequent responses were “sea level rise” (62.4%) and “ecosystem changes” (26.1%). Additionally, that study found that students perceived an increase in extreme weather events as a consequence of global warming (81.6%). [Baldwin et al. \(2022\)](#) reported that most respondents (90.0–95.0%) identified sea level rise, higher temperatures, glacier melting, animal extinction, warmer oceans, and severe weather as potential impacts of global warming, indicating strong knowledge of the macro-level impacts of climate change. Interestingly, 13.0% of respondents mistakenly indicated that COVID-19 was a potential impact, and 46.0% incorrectly identified earthquakes as a potential consequence of climate change.

Concerning perceived effects, [Baldwin et al. \(2022\)](#) found that 29.0% of participants reported personally experiencing the negative effects of climate change (including higher temperatures, wildfires, and extreme weather). These results are lower than those of the present study, where most students perceived temperature increases (60.0%) as the primary effect, followed by an increase in natural hazards (16.9%).

Society increasingly perceives the effects of climate change in everyday life, particularly through rising temperatures. This is due to the direct and tangible nature of these changes, which impact daily routines and environments. Heat waves have become more frequent and intense, disrupting work, health, and leisure activities ([IPCC 2022](#)). People experience higher energy costs for cooling, sleepless nights, and increased health risks, particularly for vulnerable groups such as the elderly and children ([Morote and Moreno-Vera 2021](#)). The rise in global temperatures also contributes to observable changes in natural ecosystems, such as earlier blooming of plants, shifts in animal migration patterns, and prolonged droughts, which directly impact agriculture and food availability ([Serrano-Notivoli et al. 2024](#)). Urban areas, due to the heat island effect, experience these temperature increases more acutely, making the problem impossible to ignore. Media coverage and local weather reports also highlight these changes, reinforcing societal awareness and concern about climate change’s immediate and tangible consequences ([Olcina et al. 2023](#)).

Finally, Hypothesis 3 proposed that participating teachers would perceive “humans as key agents in accelerating global warming”. This hypothesis is also confirmed and aligns with previous research findings ([Pickering et al. 2020](#); [Velázquez et al. 2021](#)). A notable result of this study is the minimal prominence given to denial theories. The main difference arises when comparing Spanish universities with the South American university. In the Spanish universities, participants acknowledged that climate change is natural but is now significantly influenced by human intervention. In contrast, at the Colombian university, explanations attributing climate change exclusively to human intervention were almost equally weighted with the natural explanations.

In Ecuador, [Velázquez et al. \(2021\)](#) found that respondents attributed this phenomenon to environmental degradation caused by human actions, such as contaminating the air, soil, seas, and oceans with chemical, physical, and biological components, while also creating food insecurity and increasing population vulnerability. [Pickering et al. \(2020\)](#), studying young Canadians (17–18 years old), reported that most believed in the severity and impact of global warming.

In Spain, [Sánchez-Almodóvar et al. \(2023\)](#) revealed that students see climate change as a growing threat, with extreme events becoming increasingly frequent (74.8%). [Ojala \(2021\)](#),

meanwhile, analyzed young people's trust or distrust in climate change science. According to the author, "it is particularly important to focus on trust and distrust in science" and "it is vital to view both trust and distrust among young people as forms of active engagement with climate change" (Ojala 2021, p. 288).

Society increasingly believes that humans are the main drivers of climate change rather than natural causes, due to the overwhelming body of scientific evidence pointing to human activities as the key contributors. The rapid acceleration of climate change over the past century correlates strongly with industrialization, deforestation, and the burning of fossil fuels, each of which releases greenhouse gases into the atmosphere. These human activities have significantly increased the concentration of greenhouse gases, such as carbon dioxide and methane, which trap heat and cause global warming (IPCC 2022). In contrast, natural climate variations, including volcanic eruptions and solar cycles, occur over much longer timescales and cannot account for the current rate of temperature rise. Additionally, studies show that more than 90.0% of climate scientists agree on the anthropogenic origins of climate change, lending credibility to these findings (IPCC 2022). As a result, society is more likely to attribute climate change to human actions, especially as the effects of climate change become more visible in everyday life.

5. Conclusions

The main conclusion of this study is that the majority of pre-service teachers have received training on this phenomenon during their school years (78.3%), while the percentage drops by almost half at the level of higher education (44.0%). Moreover, they report a moderate level of preparation (half of the participants selected '3' on a Likert scale (1 to 5), accounting for 54.2% of responses). For this reason, it is necessary to expand teaching-learning (T-L) about climate change in higher education to address future environmental issues in the classroom.

Our results align closely with UNESCO's (2021) report, which highlights the critical role of teacher training in preparing educators with the motivation, skills, and opportunities necessary to teach topics related to sustainable development and global citizenship. This report emphasizes the importance of empowering teachers to effectively address global challenges such as climate change. While our study identifies gaps in higher education training for future Social Science teachers, UNESCO underscores similar challenges globally, pointing to limited resources and insufficient professional development opportunities. Together, these insights stress the need for comprehensive, interdisciplinary approaches to teacher training that foster confidence and competence among educators in educating future generations about sustainability.

In addition, the formation of teachers who train pre-service teachers is crucial for ensuring high-quality teaching. These instructors shape the pedagogical methods, attitudes, and professional standards of the next generation of teachers. By providing these teachers with comprehensive, up-to-date knowledge and effective teaching strategies, they are better equipped to foster critical thinking, creativity, and a deep understanding of climate change among their students. Proper teacher training ultimately impacts the quality of education and the preparedness of future teachers for their roles in the classroom.

Students who perceive themselves as more competent in the subject employ a broader range of didactic approaches to address this topic in classrooms. Moreover, it has been observed that while teachers have theoretical clarity about the processes, causes, and effects of climate change on contemporary societies, this does not align with their level of practical competence regarding the phenomenon. This misalignment may have a limited impact on fostering environmentally responsible behaviors among future citizens educated under their guidance in schools.

In relation to the methods, a mixed questionnaire (quantitative-qualitative) has been used, which is highly appropriate and advantageous in Social Sciences research as it allows for a more comprehensive understanding of complex phenomena. Quantitative data, such as Likert-scale responses, provide measurable and comparable insights, enabling statistical analysis and trend identification. Meanwhile, qualitative responses offer deeper, context-rich information that captures participants' perspectives, motivations, and experiences in greater detail. This combination enhances the reliability and validity of the research by triangulating data from different sources, reducing biases, and providing both generalizable results and nuanced interpretations (Ortega 2023).

One limitation of this study is its focus on teaching climate change in schools from an interdisciplinary perspective. Such an approach aims to integrate knowledge from various fields to enhance students' understanding of the complexity of the phenomenon, including its causality, consequences, and potential solutions viewed from different perspectives. A key future research challenge is promoting civic education among students, enabling them to understand their role in mitigating global warming through conscious individual or collective actions. These actions could include adopting sustainable lifestyles, participating in community initiatives, and supporting responsible environmental policies, thereby empowering students to become transformative agents in the fight against climate change.

Likewise, it should be noted that this study is a preliminary exploratory analysis. Future plans include selecting a different group of students who participated in this research and conducting interviews with them. Such an approach could provide valuable insights, for example, to understand the differences between Colombia and Spain.

The findings of this research are valuable to the academic community as they identify areas for improvement in teacher training programs focused on climate change education. This would enable educational institutions to adapt their curricula and teaching strategies to better prepare future teachers with the necessary tools to effectively address this topic in the classroom.

Improving teacher training on climate change education is crucial for equipping future educators with the necessary knowledge and skills to address this global challenge effectively in the classroom. As climate change becomes an increasingly urgent issue, teachers must be prepared to guide students in exploring its causes, effects, and potential solutions. Enhancing teacher preparedness will not only foster environmental awareness but also empower students to adopt sustainable behaviors and contribute to positive societal change. Therefore, investing in professional development programs focused on climate education can strengthen the role of schools in shaping a more environmentally responsible and informed generation. Finally, it is essential to highlight that education represents one of the most important factors for adapting to climate change. Through it, present and future societies can become more resilient to the challenges posed by climate change scenarios.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki. Regarding the ethics committee, in our institution (University of Valencia), if an opinion survey is going to be carried out on some topic or issue, professional situation, satisfaction with

certain issues, etc., as long as psychological or health information is not included, authorization from the Ethics Committee is not required.

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Appendix A

Table A1. Questionnaire used in this research.

Item	Type of Response
Section 1. Socio-educational characteristics	
- Item 1. Age	- Open response.
- Item 2. Gender	- Closed response: “Men” (1); “Women” (2); “Other” (3); “I prefer not to say” (4)
Section 2. School training on climate change	
- Item 3. During your school years, did you receive any kind of training on climate change?	- Closed response: “No” (0); “Yes” (1); “I do not remember” (2).
- Item 4. If the previous answer was affirmative, during which educational stages do you recall receiving this content?	- Open response.
Section 3. The importance of media	
- Item 5. From the following sources of information listed, select the main one from which you receive the most information about climate change:	- Closed response: “Family/friends” (1); “Social media” (2); “TV” (3); “Written press” (4); “Radio” (5); “NGOs” (6); “Internet” (7); “Billboards” (8); “Academic work (University)” (9).
- Item 6. From the previously chosen source, what are the main causes of climate change mentioned? Select the most important one:	- Closed response: “Do not know/No answer” (0); “Pollution” (1); “Deforestation” (2); “Lack of human awareness” (3); “Overexploitation of natural resources” (4); “Natural causes” (5).
- Item 7. From the previously chosen source, what are the main consequences of climate change mentioned? Select the most important one:	- Closed response: “Do not know/No answer” (0); “Increase in natural hazards” (1); “Increase in invasive species” (2); “Increase in temperature” (3); “Melting and rise in sea level” (4); “Extinction of species” (5); “Depletion of natural resources” (6); “Socio-economic conflicts” (7); “Destruction of the ozone layer” (8); “Increase in diseases” (9).
- Item 8. Are so-called “fake news” stories manipulating information about climate change? Answer from 1 to 5, with 1 being ‘strongly disagree’ and 5 being ‘strongly agree’:	- Likert scale response (1 to 5).
- Item 9. If your previous answer was “Strongly agree” (5) or “Agree” (4), could you provide an example of a fake news story about climate change?”	- Open response.
Section 4. Teachers’ perceptions of climate change	
- Item 10. In your opinion, what are the main causes of climate change? Choose the most important one.	- Closed response: “Do not know/No answer” (0); “Pollution” (1); “Deforestation” (2); “Lack of human awareness” (3); “Overexploitation of natural resources” (4); “Natural causes” (5).

Table A1. Cont.

Item	Type of Response
- Item 11. In your opinion, what are the main consequences of climate change? Choose the most important one.	- Closed response: “Do not know/No answer” (0); “Increase in natural hazards” (1); “Increase in invasive species” (2); “Increase in temperature” (3); “Melting and rise in sea level” (4); “Extinction of species” (5); “Depletion of natural resources” (6); “Socio-economic conflicts” (7); “Destruction of the ozone layer” (8); “Increase in diseases” (9).
- Item 12. What effects of climate change do you perceive in your daily life? Choose the most important one.	- Closed response: “Do not know/No answer” (0); “Increase in natural hazards” (1); “Increase in invasive species” (2); “Increase in temperature” (3); “Melting and rise in sea level” (4); “Extinction of species” (5); “Depletion of natural resources” (6); “Socio-economic conflicts” (7); “Destruction of the ozone layer” (8); “Increase in diseases” (9).
- Item 13. In your opinion about climate change. . . Choose the most important one.	- Closed response: “Do not know/No answer” (0); “Climate change is caused only by human action (anthropogenic greenhouse effect)” (1); “I do not believe in climate change” (2); “Climate change has always existed, but humans are not accelerating it” (3); “Climate change has always existed, but humans are accelerating it” (4).
- Item 14. What is the main greenhouse gas? Select one.	- “Methane (CH ₄)” (1); “Ozone (O ₃)” (2); “Carbon Dioxide (CO ₂)” (3); “Water Vapor (H ₂ O)” (4); “Nitrogen Oxides (NO _x)” (5).
Section 5. Teacher training on climate change	
- Item 15. Have you previously received any training on these topics at university?	- Closed response: “No” (0); “Yes” (1); “I do not remember” (2).
- Item 16. Could you explain the reason for your previous answer?	- Open response.
- Item 17. Are you trained to teach these topics? Answer from 1 to 5, with 1 being “Strongly disagree” and 5 being “Strongly agree.”	- Likert scale response (1 to 5).
- Item 18. Is it worth teaching this content in Primary Education classrooms? Rate your opinion from 1 to 5, with 5 being the highest rating:	- Likert scale response (1 to 5).
- Item 19. Could you explain the reason for your previous answer?	- Open response.
- Item 20. What would you propose to improve your training on this content in the Primary Education Degree?	- Closed response: “Do not know/No answer” (0);
- Item 21. As a future teacher, what activities, information, etc., would you propose to your students to increase their knowledge about climate change?	- Open response.

Source: own elaboration.

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