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Knowledge and perception of Spanish school children of climate change

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ABSTRACT

One topic that is currently playing a major role in education is climate change, given its implications for raising awareness and training in present and future society. The objectives of this research are to analyse the knowledge of Spanish school children (Primary, Secondary Education and Baccalaureate) studying Social Sciences and/or Geography in terms of climate change, the causes and consequences that they identify and the effects that they perceive in their daily lives. For a sample of 1328 students surveyed between the academic year 2020–2021 and 2022–2023, the results indicate that the majority believe that climate is changing (75.0%) and the main origin of this phenomenon is pollution (46.5%). With respect to the consequences, they principally identify the increase and changes in temperatures (54.3%), and with regards the perceived effects, more than half (60.0%) perceive an increase and change in the temperature. In conclusion, the study determines what students know about this global phenomenon and whether it coincides with their experiences. This is of utmost importance due to implications it has for the education system and training the youngest cohorts about climate change.

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Introduction

Climate change, as indicated in the last report of the Intergovernmental Panel on Climate Change (IPCC 2022a), is one of the principal challenges faced by society in the twenty-first century. This report prioritises the adaptation to this phenomenon and its mitigation, due to its derived effects (increase in temperature, loss of climate comfort, intensification of extreme weather events, etc.). Future of society (children, families, etc.) depends, partly, on becoming aware of this serious problem (Morote and Olcina 2023; Ojala 2021; Verlie and Blom 2022; Woo 2022). Therefore, raising awareness and educating about climate change with rigour is of concern and interest to the community and, in particular, the educational field (Dunlop and Rushton 2022; Ojala 2022; Sánchez-Almodóvar, Gómez-Trigueros, and Olcina 2023; Verlie and Blom 2022).

Verlie and Blom (2022) claim that education can improve our ability to proactively respond to the changing climate in which children now live. These authors believe that foregrounding the affective materiality of climate in concepts such as ‘classroom climate’ and ‘school climate’ can help ensure that: ‘(1) affective experiences of climate change are focused on climate change education; and (2) education systems can enable and empower children to proactively respond to their changing world/s’ (Verlie and Blom 2022, 622).

As indicated by Ojala (2021), there has been great public interest in youth as an important stakeholder group regarding climate change. This population is seen either as saviours who, through their involvement in 'Fridays for Future' and the global school strikes, will rescue us, or as an especially vulnerable group regarding climate anxiety (Sanson, Van Hoorn, and Burke 2019).

Some authors (Sánchez-Almodóvar, Gómez-Trigueros, and Olcina 2023) have pointed out that education is one of the most important non-structural factors for adapting to and addressing this phenomenon. However, as explained by Morote and Olcina (2023), education still does not receive enough attention in climate change policies, which prioritise structural measures and CO₂ reduction policies.

The importance of the role of education in addressing climate change has been indicated by different international entities. In its fifth report (IPCC 2014), the IPCC had already pointed out that education was one of the fundamental actions for adapting societies to climate change. Its sixth report is also related to the importance of its mitigation (IPCC 2022b). In addition, the United Nations (UN 2015) identifies this variable (education) as one of the most important elements when mitigating the effects of climate change (Sustainable Development Goal n. 13 'Climate Action'). Similarly, it refers to Articles 11 and 12 of the Paris Agreement (2015) (United Nations, Climate Change 2015), which replicate the content of Article 6 ('Education, training and public awareness' of the UN Framework Convention on Climate Change 1992).

For the Spanish case, this issue has also been an object of legal interest in educational law. For the first time, the Spanish Climate Change Law (approved in May 2021) dedicates a section to teaching, specifically Title VIII ('Education, Research and Innovation in the fight against climate change and energy transition'). In the same way, the new Education Law (LOMLOE, Organic Law 3/2020 of 29 December) places greater emphasis on the contents on sustainability and territorial resilience.

In relation to society's conception of climate change, the influence of the mass media is particularly noteworthy (Morote, Campo, and Colomer 2021). One of the consequences of this is the proliferation of so-called 'fake news' and stereotypes that have arisen in the social representation of the youngest cohorts. In fact, Morote, Campo, and Colomer (2021) find that the information acquired by the majority of trainee teachers has been drawn from the Internet, the television and social networks (90.0%). Meanwhile, the information drawn from the family environment amounts to 1.6%. In relation to these information sources, Lutzke, Drummond, and Arvai (2021) highlight the danger of receiving unreliable information that lacks rigour and is based on fake and manipulated news.

In Spain, Geography teaching uses an abundance of scientific production on Climatology (Martínez-Fernández and Olcina 2019), but not on climate change, except for some recent publications that have been carried out from three perspectives: (1) social representations of the students (Sánchez-Almodóvar, Gómez-Trigueros, and Olcina 2023) and trainee teachers (Morote, Campo, and Colomer 2021); (2) analysis of the contents of school textbooks (Olcina 2017); and (3) didactic proposals. On an international level, there are many publications on the teaching of this phenomenon: Central and North America (Sezen-Barrie and Marbach-Ad 2021), Europe (Stasewitsch, Dokuka, and Kauffeld 2022), Africa (Anyanwu and Grange 2017), Asia and Oceania (Li and Liu 2021; Verlie and Blom 2022) or South America (Canaza, Escobar, and Arohuana 2021; Núñez 2021).

Furthermore, in relation to the study of climate change in schools, some authors have conducted climate change surveys among students in order to determine their degree of knowledge about this process, for example: Baldwin, Pickering, and Dale (2022), Busch et al. (2019), Hermans and Korhonen (2017), Hickman et al. (2021), Pickering, Schoen, and Botta (2021) and Ojala (2021). This last study, for example, is focused on how the emotional dimension of trust in climate change science plays a role in engagement on two levels: (1) how young people relate to climate change in general and whether they worry about or deny climate change; and (2) how young people address ambivalence towards behavioural advice, for example, climate-friendly food choices. Other articles refer to the teaching of climate change in schools and the reticence of teachers to engage in climate change instruction (Verlie and Blom 2022).

The objectives of this research are to analyse, for the case of Spanish school children (Primary Education—3rd cycle, 6–12 years old—, Secondary Education—12–16 years old—, and Baccalaureate—16–18 years old) studying Social Sciences and/or Geography in Spain: (1) what they know about climate change; (2) the causes and consequences that they identify with respect to this phenomenon; and (3) the effects that they perceive in their daily lives.

With respect to the starting hypothesis, it should be pointed out that the students would have limited knowledge about climate change, and this would be related to an effect of human malpractice (hypothesis n. 1). This hypothesis is also proposed in publications such as that of Calixto (2018). As already indicated, by limited knowledge, we understand that the students do not identify all or the majority of either the causes or the consequences of climate change, but only partially and with numerous mistakes. With respect to the causes that they are expected to identify, these would be related to human action (mainly pollution), while the effects would be the increase in temperature, an increase in the sea level, melting, etc., that is, catastrophic effects (hypothesis n. 2), also noted in other works (Sánchez-Almodóvar, Gómez-Trigueros, and Olcina 2023). With respect to the perceived effects, these would be extreme weather events (hypothesis n. 3) as also stated by Sánchez-Almodóvar, Gómez-Trigueros, and Olcina (2023). In other words, there would be a direct relationship between the effects of climate change that they know and what they perceive in their daily lives. Furthermore, it is worth pointing out that the cognitive age of the students would influence the responses. For this reason, also noted by Zamorano et al. (2009), the opinions of the Baccalaureate students (16–18 years old) would be more accurate in terms of the explanation of global warming (hypothesis n. 4).

This research is of interest for an international audience for different reasons. First, because its objective is to determine, for the Spanish case, the perception and knowledge that school students have about climate change; a topic of great interest given its impact on the planet. This information is notably relevant since, the measures adopted in the future will most likely depend on their degree of knowledge and awareness. The second reason is related to whether this knowledge (effects) coincides with what they perceive in their daily life. Advancing in this knowledge is relevant as the effects of climate change on the students' daily lives and immediate surroundings will foster an awareness among them and encourage them to modify it. Finally, to determine whether there are differences according to the stage of schooling (Primary Education, Secondary Education and Baccalaureate). The results obtained here can be used to make comparisons with other studies that have analysed similar issues in other international contexts with different educational systems and climatic contexts.

Methodology

Design of the research

This study takes a socio-critical approach in which different aspects are investigated associated with the relations and impacts of society on the surrounding territory. For example, in this case, the social representations that school students have of climate change. This approach has been used for several decades, both from the Anglo-Saxon (Evans, Newman, and Saxe 1996) and French (Legardez 2006) spheres. With regard to the study design, it mixes an explanatory and correlational methodology (not experimental) (Moreno-Vera, Ponsoda, and Blanes 2021). Moreover, with respect to the temporal dimension, it is a transversal study as the information obtained has been grouped and gathered at different moments (academic years 2020–2021, 2021–2022 and 2022–2023) (Colás and Buendía 1998).

Description of the context and the participants

The selection of the students was carried out through a non-probabilistic sampling (available or convenience sampling) of three academic years (between 2020–2021, 2021–2022 and 2022–

2023). The participants in this study are Primary Education students (3rd cycle: 10–12 years old), Secondary Education students (12–16 years old) and Baccalaureate students (16–18 years) from Primary schools ($n = 4$) and Secondary Education centres ($n = 4$) in the Region of Valencia (Spain). In all of these years, the participants were studying the subject of Social Science and/or Geography. The Region of Valencia has been chosen because the different schools studied in this research are located in this region. Second, because different studies have also been developed within this line of research in this region.

The total number of students enrolled in these years was 1,785: Primary Education ($n = 410$), Secondary Education ($n = 850$) and Baccalaureate ($n = 525$). With respect to the representativeness of the sample, taking into account the total number of students registered (1785 students), in order to achieve a confidence interval of 99% and a margin of error of 5% a minimum of 486 respondents was required. Finally, a total of 1328 students participated, giving rise to a representative sample (see Table 1). In relation to the characteristics from a gender point of view, the figures are similar: boys (52.4%; $n = 696$); girls (47.6%; $n = 632$). The average age of the whole sample is 13.4 years. In order to analyse the results, they have been grouped by educational stages and not by years since we are not performing trend research.

Research instrument

In order to fulfil the proposed objectives of this study, a mixed questionnaire (quantitative–qualitative) was designed. This questionnaire was validated by three researchers from different education (Social Sciences) and geography departments of Spanish universities. The questionnaire was made up of three blocks with a total of 12 items: Block (1) training on climate change; Block (2) perception of climate change; and Block (3) solutions and proposals for adapting to global warming. For this article, we focused on Block 2: items 5 and 6 (specific objective n. 1), items 7 and 8 (specific objective n. 2) and Item 9 (specific objective n.3) (see Appendix 1). The questionnaire contains closed and open-answer questions, and others on a Likert scale. For example, items 5 and 9 are open-answer questions, but in order to carry out the statistical analysis (SPSS v.28) we have categorised them.

In order to assess the construct validity of the questionnaire, several procedures were carried out. First, a statistical analysis of the ordinal variables was conducted. For these variables, it was found that there was an acceptable standard deviation as the value obtained was between $0 > 1$. Second, the Kaiser-Meyer-Olkin (KMO) validity test was performed on the construct in order to determine whether the factor analysis of the instrument was acceptable or not. The KMO test gave a positive result of 0.507, which, according to other factor reliability studies, is considered to be an acceptable level (Pérez-Gil, Moscoso, and Rodríguez 2000). Third, as the questionnaire was mixed (quantitative and qualitative), the Friedman Chi-squared test was conducted (Friedman’s χ^2 test). This test gave a positive value of $p = 0.001$, far from zero ($p < 0.05$), indicating that there was no discrepancy between the variables. Therefore, the variables are dependent on one another (Sharpe 2015). This gives a positive reliability value to the research, coinciding with other studies on the teaching of Social Sciences (Moreno-Vera, Ponsoda, and Blanes 2021).

Table 1. Students who participated in the research.

	Registered (n)	Participants (n)	Average age	Gender	
				Male	Female
Primary Education	410	378	10.7	54.2% ($n = 205$)	45.5% ($n = 172$)
Secondary Education	850	673	13.4	53.6% ($n = 361$)	46.4% ($n = 304$)
Baccalaureate	525	277	16.9	46.9% ($n = 130$)	53.1% ($n = 147$)
Total	1,785	1,328	13.4	52.4% ($n = 696$)	47.6% ($n = 632$)

Source: Questionnaire results. Own elaboration.

Procedure and data analysis

The questionnaire used in this study was administered during an intermediate session (second semester of the academic years 2020–2021, 2021–2022 and 2022–2023) in the subject of Social Sciences (Primary Education) and Geography (Secondary Education and Baccalaureate), with a response time of 10 min.

For this research, we have followed certain ethical criteria implemented in the data collection process (Hirsch and Navia 2018). It should be noted that the whole procedure was carried out preserving the anonymity of the participants according to Organic Spanish Law 3/2018 of December 5, with the elaboration of a list of the students by numbers and guaranteeing in writing the confidential treatment of the information.

With regard to the data analysis procedure, the SPSS v.28 programme was used to conduct a statistical-inferential analysis (non-parametric testing) of frequencies and percentages. In order to conduct the non-parametric testing, the Kruskal–Wallis H and the Chi-squared test (χ^2) were used. Moreover, the opinions in the open answers (qualitative information) of items 5 and 9 have been coded. In order to collect direct opinions from the students, a code was also used, with letters being assigned to the educational level (PE, SE and B for Primary Education, Secondary Education, and Baccalaureate, respectively) and numbers to the students.

Results

The students' knowledge of climate change

The results of analysing of students' knowledge of climate change (Item 5) reveal that there is a variety of opinions. On the one hand, some insist that this phenomenon is a change of climate (but without mentioning human action at any time; option n. 4) (34.5%; $n = 458$). On the other hand, others believe that climate change is a phenomenon resulting from human action (option n. 2; 30.3% $n = 402$). Furthermore, it is worth highlighting that 17.2% ($n = 228$) did not know how to respond to this question (see Table 2).

When analysing whether there are differences in the responses depending on the school stage (Primary, Secondary, Baccalaureate) (Table 2), Baccalaureate students responded more with option n. 2 ('changes in the climate due to human action') (44.4%; $n = 123$). On the other hand, Primary Education participants responded more frequently with option n. 4 ('change in climate—without mentioning human action') (41.0%; $n = 155$). In order to verify whether there are statistically significant differences between these responses (knowledge of climate change) and the school stage of the students, the Chi-squared test was conducted. This test shows that the association between these two variables is significant (Pearson's Chi-squared = 62.477; $p = 0.001$). Therefore, they are associated significantly ($p < 0.05$) and they are dependent variables.

Second, the results of analysing Item 6 ('Do you think that the climate is changing?') reveal that the majority of the students gave a positive response to values 4 and 5 (see Table 3). The

Table 2. Responses to what climate change is (Item 5) according to the school stage of the students.

School stage		0	1	2	3	4	Total
Primary Education	<i>N</i>	54	39	95	35	155	378
	%	14.3%	10.3%	25.1%	9.3%	41.0%	100.0%
Secondary Education	<i>N</i>	147	35	184	83	224	673
	%	21.8%	5.2%	27.3%	12.3%	33.3%	100.0%
Baccalaureate	<i>N</i>	27	16	123	32	79	277
	%	9.7%	5.8%	44.4%	11.6%	28.5%	100.0%
Total	<i>N</i>	228	90	402	150	458	1,328
	%	17.2%	6.8%	30.3%	11.3%	34.5%	100.0%

Source: questionnaire results. Own elaboration. Coding of item: 0 ('Do not know/No answer'); 1 ('Problem that affects the planet'); 2 ('Changes in the climate due to human action'); 3 ('Greenhouse effect/global warming'); 4 ('Changes in the climate -without mentioning human action-').

Table 3. Responses to whether the climate is changing (Item 6) according to the school stage of the students.

School stage		1	2	3	4	5	Total
Primary Education	<i>n</i>	5	14	97	138	124	378
	%	1.3%	3.7%	25.7%	36.5%	32.8%	100.0%
Secondary Education	<i>n</i>	8	24	144	240	257	673
	%	1.2%	3.6%	21.4%	35.7%	38.2%	100.0%
Baccalaureate	<i>n</i>	5	12	23	94	143	277
	%	1.8%	4.3%	8.3%	33.9%	51.6%	100.0%
Total	<i>n</i>	18	50	264	472	524	1,328
	%	1.4%	3.8%	19.9%	35.5%	39.5%	100.0%

Source: questionnaire results. Own elaboration. Likert Scale (1–5) response question, where 1 is ‘completely disagree’ and 5 ‘completely agree’.

observations in Table 5 reveal that the Baccalaureate students responded more with value 5 (51.6%; $n = 143$). In order to determine whether there are statistically significant differences depending on the school stage (Primary Education, Secondary Education, Baccalaureate), the Kruskal–Wallis H test was carried out. This test indicates that there is significance (Kruskal–Wallis $H = 29.238$; $p = 0.001$).

Causes and consequences of climate change identified by the students

The results of analysing the causes (Item 7) and consequences (Item 8) reveal that the main cause of this phenomenon is pollution (46.5%; $n = 618$) followed by human action (34.2%; $n = 454$) (see Table 4). If these data are analysed in accordance with the school stage, it can be observed that the percentage of the ‘human action’ responses increase as the age of the students increases. Furthermore, it can be also seen that the number of ‘no response’ decreases as the school stage advances, which could indicate that the students acquire knowledge over time.

For the case of ‘pollution’ responses, no significant differences can be appreciated in relation to the school stage (Table 4). Some of the responses of the students on these causes are: ‘Car pollution’ (PE57); ‘fuel, smoke, rubbish’ (PE65); ‘excessive use of transport’ (B14). Some of the responses regarding ‘human action’ are: ‘consumerism’ (B1); ‘lack of awareness’ (B68); ‘low level of social awareness’ (B104). These responses are related to a greater responsibility and a more critical perspective of the impact of society on the environment.

In order to verify whether there are statistically significant differences between these responses (causes) and the school stage of the students, the Chi-squared test was conducted. This test shows that the association between these two variables (causes and school stage) is significant (Pearson’s Chi-squared = 80.520; $p = 0.001$). Therefore, they are associated significantly ($p < 0.05$), and they are dependent variables.

With respect to the consequences (Item 8), if the overall data are taken into account (1328 responses), they indicate that the main effect of climate change is the increase and change in temperatures (54.3%; $n = 721$) and, in second place, but with considerably lower figures, are the responses related to melting (10.2%; $n = 136$) (see Table 5).

When analysing whether there are differences between the school stage of the students, differences can be observed. For example, in the responses related to the increase in temperatures. Table 5 shows that as the students get older, the percentage of these responses increases: Primary Education (40.2%), Secondary Education (57.9%) and Baccalaureate (64.6%). Furthermore, it can also be observed that the number of ‘no responses’ decreases as the school stage advances, which could indicate that the students acquire knowledge over time. The same is the case for Item 7 (causes). Some of the opinions on the increase in temperatures are: ‘it is becoming increasingly hotter in Alicante in the winter, it is practically spring all year round’ (PE2); in the summer the temperatures are over 40° (SE96); ‘there is hardly any autumn or spring anymore’ (B80).

Table 4. Causes of climate change (Item 7) in accordance with the school stage of the students

Causes		Primary education	Secondary education	Baccalaureate	Total
0	<i>N</i>	28	55	7	90
	%	7.4%	8.2%	2.5%	6.8%
1	<i>n</i>	90	237	127	454
	%	23.8%	35.2%	45.8%	34.2%
2	<i>n</i>	187	302	129	618
	%	49.5%	44.9%	46.6%	46.5%
3	<i>n</i>	6	7	3	16
	%	1.6%	1.0%	1.1%	1.2%
4	<i>n</i>	18	19	2	39
	%	4.8%	2.8%	0.7%	2.9%
5	<i>n</i>	16	6	7	29
	%	4.2%	0.9%	2.5%	2.2%
6	<i>n</i>	17	18	1	36
	%	4.5%	2.7%	0.4%	2.7%
7	<i>N</i>	14	29	1	44
	%	3.7%	4.3%	0.4%	3.3%
Total	<i>N</i>	378	673	277	1,328
	%	100.0%	100.0%	100.0%	100.0%

Source: questionnaire results. Own elaboration. Coding of item: 0 ('Do not know/No answer'); 1 ('Human action'); 2 ('Pollution'); 3 ('Deforestation'); 4 ('The use of plastics'); 5 ('The overexploitation of natural resources'); 6 ('Natural causes'); 7 ('Others').

In order to verify whether there are statistically significant differences in terms of the school stage of the students, the Chi-squared test was conducted. This test shows that the association between these two variables (consequences and school stage) is significant (Pearson's Chi-squared = 113.293; $p = 0.001$). Therefore, they are associated significantly ($p < 0.05$), and they are dependent variables.

Perception of climate change in daily lives

The results of the responses of Item 9 ('Could you indicate any effects of climate change that you notice?') reveal that the majority of students perceive the increase in temperature as an effect (60.0%; $n = 797$), followed by the increase in natural hazards (16.9%; $n = 224$). In third place are the responses of 'no response or did not know how to respond' (12.9%; $n = 171$) (Figure 1).

Table 5. Consequences of climate change (Item 8) in accordance with the school stage of the students.

Consequences		Primary education	Secondary education	Baccalaureate	Total
0	<i>N</i>	30	71	6	107
	%	7.9%	10.5%	2.2%	8.1%
1	<i>N</i>	152	390	179	721
	%	40.2%	57.9%	64.6%	54.3%
2	<i>n</i>	26	28	12	66
	%	6.9%	4.2%	4.3%	5.0%
3	<i>n</i>	30	70	36	136
	%	7.9%	10.4%	13.0%	10.2%
4	<i>N</i>	43	41	25	109
	%	11.4%	6.1%	9.0%	8.2%
5	<i>N</i>	7	6	5	18
	%	1.9%	0.9%	1.8%	1.4%
6	<i>n</i>	54	36	9	99
	%	14.3%	5.3%	3.2%	7.5%
7	<i>N</i>	10	5	1	16
	%	2.6%	0.7%	0.4%	1.2%
8	<i>N</i>	25	26	4	55
	%	6.6%	3.9%	1.4%	4.1%
Total	<i>N</i>	378	673	277	1,328
	%	100.0%	100.0%	100.0%	100.0%

Source: questionnaire results. Own elaboration. Coding of Item: 0 ('Do not know/No answer'); 1 ('Increase in temperature'); 2 ('Increase in sea level'); 3 ('Melting'); 4 ('Increase in natural hazards'); 5 ('More diseases'); 6 ('Extinction of species'); 7 ('None'); 8 ('Others').

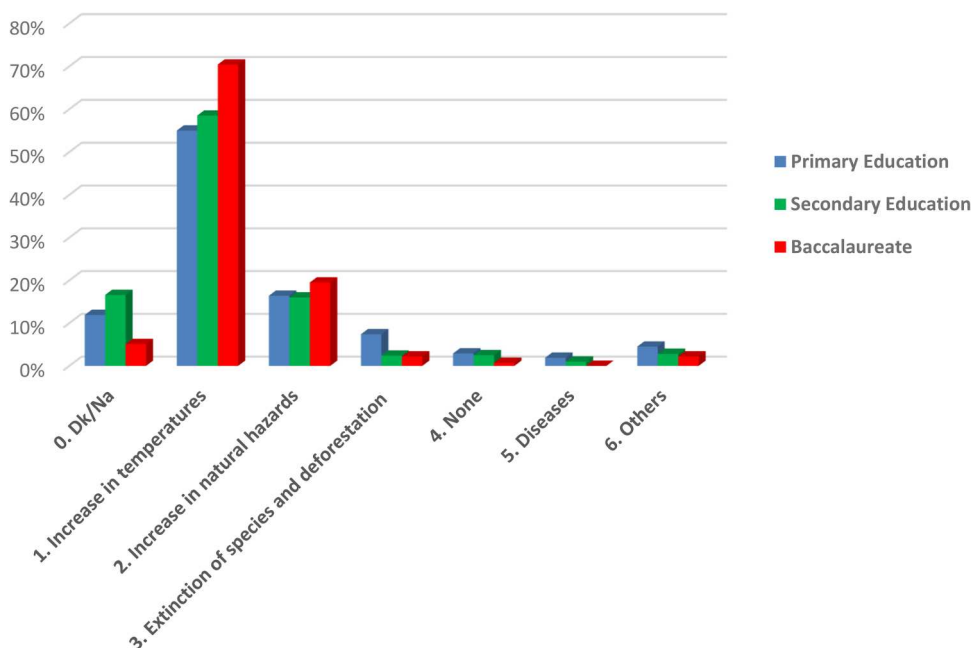


Figure 1. Responses regarding the perceived effects of climate change (Item 9) according to the school stage of the students. Source: Questionnaire results. Own elaboration. Coding of the Item: 0 ('Do not know/No answer'); 1 ('Increase in temperatures'); 2 ('Increase in natural hazards'); 3 ('Extinction of species and deforestation'); 4 ('None'); 5 ('Diseases'); 6 ('Others').

When analysing whether there are differences in accordance with the school stage of the students, differences can be noted in the responses related to the increase in temperatures. Furthermore, it can be observed that as the students grow older, the percentage of these responses (perception of the increase in temperature) increases: Primary Education (55.0%), Secondary Education (58.5%) and Baccalaureate (70.4%).

In order to determine whether there are statistically significant differences, the Chi-squared test was carried out. This test shows that the association between these two variables (school stage and perceived effects) is significant (Pearson Chi-squared = 59.993; $p = 0.001$). Therefore, this indicates that the two variables are dependent on one another.

This study has also conducted different tests to verify the possible relationship between variables. To determine the relationship between Item 6 ('Do you think that the climate is changing?') and Item 9 ('Could you indicate any effects of climate change that you notice?'). The Kruskal–Wallis H test was carried out. This test indicates that there is significance (Kruskal–Wallis $H = 42.598$; $p = 0.001$). Furthermore, the Chi-squared test was also performed to verify whether there was a statistically significant difference between Item 8 ('What do you think are the main consequences of climate change?') and Item 9 ('Could you indicate any effects of climate change that you notice?'). The objective is to determine whether the knowledge of the students of the effects of climate change coincides with what they perceive in their daily lives. The Chi-squared test shows that the association between these two variables is significant (Pearson's Chi-squared = 273.573; $p = 0.001$). Therefore, this indicates that the two variables are dependent on one another.

Discussion

This study takes a step further in determining the knowledge and perception that school children have of climate change. The starting hypothesis is partially verified: 'the students would have limited knowledge about climate change and this would be related to an effect of human malpractice'. The

results of this research reveal a disparity of opinions: there are those who associate it with a change in climate, but without mentioning human action at any time, and others believe that this phenomenon is a result of human action. Results similar to those of this study are observed in other publications. In Australia, Baldwin, Pickering, and Dale (2022) conducted an online survey of 425 youth. They found that although participants reported a high level of understanding of the impacts, they had significant knowledge gaps regarding the most effective measures to mitigate global warming. The majority of participants (85.0%) indicated the belief that the global climate is changing, and 68.0% indicated that it was completely or mainly caused by humans. Just 4.0% indicated that climate is not changing, and only 3.0% that the effect of this phenomenon is unrelated to human involvement. This is consistent with Pickering et al. (2020), who, using data on Canadian youth, illustrated that the majority of young people believe in the severity and impact of global warming. Based on a survey of 487 students in Canada (17–18 year old's; $n = 487$), these authors reveal that acceptance of climate change and its anthropogenic origins were high.

In Spain, the study by Sánchez-Almodóvar, Gómez-Trigueros, and Olcina (2023) surveying 586 students, reveals that 74.8% believe that climate change is a threat and that extreme phenomena are increasing. However, it also finds that another 10.9%, while believing that climate change is a threat, are not sure that more extreme weather phenomena are occurring now. In relation to the total data, it should be pointed out that 5.7% believe that climate change is not a threat. These results also coincide with those obtained in Spain by Zamorano et al. (2009), who identify a high level of concern among Secondary students about environmental problems on different scales (their town, state, country, and the world).

The work conducted by Hickman et al. (2021) (a total of 10,000 children surveyed between 16 and 25 years old) in ten countries (Australia, Brazil, Finland, France, India, Nigeria, Philippines, Portugal, the UK, and the USA; 1000 participants per country-) finds that respondents from all countries were worried about climate change: 59.0% were very or extremely worried and 84.0% were at least moderately worried. In comparison with our research, a disparity of opinions has been identified: some insist that this phenomenon is due to a change of climate (but without mentioning human action at any time (34.5%)); others believe that climate change is a phenomenon resulting from human action (30.3%).

Ojala (2021) discusses young people's trust or distrust in climate change science. In the words of the author 'it is particularly important to focus on trust and distrust in science' and 'it is vital to see both young people's trust and their distrust as a form of active engagement with climate change' (288). Verlie and Blom (2022) explain that the meteorology and climate are not just topics that children learn about through scientific or constructivist curricula. Jones and Davison (2021) found students were considerably frustrated by the lack of political engagement provided in climate change education and were left feeling disempowered. However, as indicated by Rousell and Cutter-Mackenzie-Knowles (2020), the significance and importance of an affectively attuned approach to climate change education is increasingly, being recognised, albeit slowly.

Hypothesis n. 2 proposes that 'with respect to the causes that they are expected to identify, these would be related to human action (mainly pollution), while the effects would be the increase in temperature, sea level, melting, etc., that is, catastrophic effects'. The results of this study verify this hypothesis: students believe that the main origin of this phenomenon is pollution (46.5%), followed by human action (34.2%). In any case, causes in which negative actions of society are present.

This is consistent with the study of Baldwin, Pickering, and Dale (2022). These authors find that most respondents accurately identified fossil fuels for transport and electricity (59.0%) and deforestation (59.0%) as major contributors to global warming. However, a similar percentage (59.0%) incorrectly identified waste pollution as a major contributor to this phenomenon, and 42.0% incorrectly identified the ozone layer hole as a major contributor. Moreover, the analysis reveals that female are more likely than males to identify each of the eight possible contributing factors as major contributors. Continuing this line of argument, for the case of Mexico, Calixto (2018) finds that the majority of students acknowledge the influence of human beings on the origin of

climate change (pollution and deforestation), but also that there are students who focus their attention solely on the consequences (melting, destruction of the ozone layer, droughts), that is, they have a partial or incomplete understanding of this phenomenon.

According to the study by Sánchez-Almodóvar, Gómez-Trigueros, and Olcina (2023), the students consider that climate change is a threat to human beings and believe that anthropogenic action is the main cause (91.3%). The second most chosen answer was 'natural factors' with only 5.3% of the responses. The answers related to 'natural origin' accounted for 1.5%. Human origin is also the main response given in the study by Escoz, Gutiérrez-Pérez, and Meira (2020) (Spain and Portugal) and in that of Chang and Pascua (2015) for Asia. Similarly, Jamelske, Barrett, and Boulter (2013) compare the opinion of Chinese and American university students regarding whether the main causes of global warming are human or natural: 86.4% of the Chinese students believe that climate change has anthropogenic causes, while barely 59.0% of the American also believe this to be the case. In contrast, only 38.0% of university students in Taiwan identify anthropogenic activity as a cause of global warming (Li and Liu 2021).

In relation to the effects, the results show that the main effect is the increase and change in temperature (54.3%), followed by the responses related to melting (10.2%). These data are similar to the research of Morote, Campo, and Colomer (2021), which examines trainee Secondary Education teachers. These authors show that the increase in temperature and natural hazards (extreme weather events) are predominant. It should be noted that in Spain, in recent years (especially since 2021 and 2023) records have been broken, that is, the maximum temperatures have exceeded the maximum values on record in Spain. This issue has appeared frequently in the media (Agencia Estatal de Meteorología [AEMET] 2023).

In relation to the effects, Sánchez-Almodóvar, Gómez-Trigueros, and Olcina (2023) also reveal that the most frequent answer was 'increase in sea level' (62.4%), followed by 'changes in the ecosystems' (26.1%), and finally, the option with the lowest frequency in this group was 'melting of the mountain glaciers' (6.9%). This is consistent with Bello et al. (2021), who examine the social representations of baccalaureate students in Mexico, finding that the increase in temperature (40.7%), the greater presence of extreme weather events (48.2%), and the increase in sea level (62.4%) are the consequences of climate change most recognised by the participants in their survey. According to Baldwin, Pickering, and Dale (2022), most of their respondents (90–95%) accurately identified rising sea levels, hotter temperatures, melting glaciers, animal extinction, warmer oceans and severe weather as possible impacts of global warming, demonstrating sound knowledge of the impacts of climate change at the macroscale. Moreover, these authors reveal that 13.0% indicated that Covid-19 was a potential impact, and 46.0% incorrectly identified earthquakes as a potential impact of climate change. In Finland, based on data collected from 549 students (secondary school), Hermans and Korhonen (2017) reveal that the students regard climate change as a risk. Worry about climate change consequences has been linked to students' willingness to act (Boyes and Stanisstreet 2012; Chhokar et al. 2012), but when controlling for other effects, worry has not had significant effects in previous research (Ojala 2010).

Hypothesis n. 3 indicates that

the effects that the students perceive would coincide with the consequences of climate change that they identified in their responses (extreme weather events). In other words, there would be a direct relationship between the effects of climate change that they know about and what they perceive in their daily lives.

This hypothesis is fulfilled. Similar results have been obtained in different publications that analyse the perception of students (Sánchez-Almodóvar, Gómez-Trigueros, and Olcina 2023). The latter study shows that students perceive an increase in extreme weather events as a result of global warming (81.6%). In the research of Baldwin, Pickering, and Dale (2022) conducted in Australia, approximately 29.0% of participants indicated that they had personally experienced the negative effects of climate change (higher temperatures, bushfires, and extreme weather events), whereas 48.0% indicated that they were 'unsure' and 22.0% indicated that they had had no experiences. In this latest

publication, the results are lower than those obtained in our research: the majority of students perceive as an effect the increase in temperature (60.0%), followed by the increase in natural hazards (16.9%).

With respect to the statement that global warming is a threat to life, the results of the current study coincides with those obtained by Morote, Campo, and Colomer (2021), with university students who consider that this phenomenon occurs and is expressed in our daily lives. However, the research conducted in Turkey (Primary Education) finds that only 41.0% of the students perceive climate change as a threat, while 40.0% are not sure and 19.0% consider that they are not affected or will not be affected (Özdem et al. 2014). Other studies about the perception of the effects of climate change (Hickman et al. 2021) reveal that more than 45.0% of respondents said their feelings about global warming negatively affected their daily life and functioning, and many reported a high number of negative thoughts about climate change: 75.0% said that they think the future is frightening, and 83.0% said that they think people have failed to take care of the world. These authors attributed this to the failure of governments to take action, resulting in impacts on younger generations and thus constituting moral injury.

In the study by Rooney (2019, 181), work exploring children's experiences in 'wild weather times' is a notable exception to educational engagements with the meteorological and atmospheric. This author notes that taking children outside the classroom and 'focusing on the bodily effects of elemental conditions such as rain, wind and sunshine in environmental pedagogies is ... one way in which we might open opportunities for children to become alert to the flux of climatic activity' (Rooney 2018, 5).

Ojala (2021, 288) explains that 'socioeconomic factors, gender, place attachment, personality dimensions, general social trust, cultural norms, and so on, could play a role' and indicates that in-depth studies are needed to explore the role that trust/distrust in climate change science plays in the coping efforts and identity development of young people. This author also affirms that 'youth are not passive victims of climate change worry but in fact actively cope' (Ojala 2021, 285). Fridays for Future expresses a high degree of trust in climate science, and science 'is put in opposition to an otherwise cynical view of the adult world, especially young people's view of politicians' Ojala (2021, 287).

For this reason, it is important to analyse what schoolchildren know, as well as improve their training in climate change. In this way, a more resilient society could be formed and educated in issues regarding global warming. Hence, the importance of addressing these issues in the family environment as part of the endeavour to raise awareness among the youngest members. In this sense, it is worth referring to Morote, Campo, and Colomer (2021) who finds that only 1.6% of students received information about climate change from their families.

Hypothesis n. 4 indicated that 'furthermore, it is worth pointing out that the cognitive age of the students, a priori, should influence the responses. For this reason, the opinions of the Baccalaureate students (16–18 years old) would be more accurate in terms of the explanation of global warming'. This study has revealed that the school stage influences both the knowledge and perception of climate change. For example, it has been shown that as the age of the students increases, the responses 'Dk/Na' become less frequent. However, Morote and Hernández (2022) shows that, as the age of the students increases, the number of errors and incorrect concepts about global warming increases, due to a greater access to false information through social networks and the Internet. Also, in comparison with our research, it can be observed that as the students grow older, the percentage of the responses about the perception of the increase in temperature, increases: Primary Education (55.0%), Secondary Education (58.5%) and Baccalaureate (70.4%).

Conclusions

Based on the responses of Spanish school children studying Social Sciences and/or Geography, this study reveals that the majority believe that climate is changing due to pollution (human origin). Furthermore, it has also been verified that a large part of the students does not think that climate change

can also be due to natural causes (as in the past). A third element to highlight are the students who have not been able to answer to this question. With respect to the consequences, the main effect is the increase and change in temperature, which, in turn, coincides with what they perceive in their daily lives.

This research shows that the beliefs and perceptions of the participants towards the effects of climate change are very similar to those in other territorial contexts (increase in the temperature, natural hazards, rising sea level). This shows that climate change is a global phenomenon with consequences that are manifested throughout the world. In addition, it verifies how the knowledge of the students on this subject but also their perception of this phenomenon, differs depending on their age. The results analysed here have been drawn from the perception and opinion of the students, but how they are taught about climate change in the classroom is unknown. This is one of the limitations of this study. Another limitation is that we have not been able to determine whether there have been students who have completed the same questionnaire in subsequent years (for the case of the Secondary Education or Baccalaureate). Other limitations of the research could include the study design (mixed explanatory and correlational study) as it cannot be generalised to all Spanish students, or the lack of multiple answers to questions that could have offered a greater variety of answers. Some issues that must be considered in future research are the growing relevance that education in climate change has acquired as a non-structural measure to alleviate its effects.

Verlie and Blom (2022) affirm that if the education system wishes to be relevant to children's lives, then, as the school strikers are proclaiming, it needs to acknowledge that humans form part of a grand interspecies community, which is true for classrooms as much as the wider world. For this reason, it is important to involve families in the process of raising awareness among schoolchildren on the issue of climate change. Ojala (2021) explains the need for more research about what role trust/distrust in climate change science plays in young people's everyday climate engagement, meaning-making and identity development, but also taking into account the families. For this reason, Verlie and Blom (2022) reveal the urgent need to revise education by first acknowledging that we all live in changing climates and that this reality is particularly pertinent for children who are growing up in a rapidly warming world.

Working with children's lived experiences of climatic disruption to cultivate pedagogies and curricula that adequately support, care and empower them to create climate just futures is evidently a challenging but urgent task. Yet this is unlikely to be made easier by ignoring children's multifaceted everyday experiences of climate change. (Verlie and Blom, 2022, 628)

For this reason, one future research challenge would be to conduct interviews with active teachers in order to learn how they are really teaching this content and the methodologies and resources used. A second challenge would be to analyse what students perceive from the media and to determine whether this information coincides or not with what they receive in the classroom. Additional aims for future research could focus on the best techniques for educators to use in relation to teaching climate change and to motivate students to act. It is important to improve the teaching of climate change and to take this phenomenon into account in the educational context so as to raise awareness among present and future generations. This is of utmost importance in order to raise awareness and train the youngest cohorts about climate change, which should be taught in schools in a simple yet rigorous way.

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Appendix

Appendix 1. Items of the questionnaire analysed and relevant studies

Block 2. Perception of climate change		
Question topic	Type of response	Authors
Item 5. What is climate change?	Open answer question.	Morote, Campo, and Colomer (2021), Sánchez-Almodóvar, Gómez-Trigueros, and Olcina (2023).
Item 6. Do you think that the climate is changing? (mark with an X). Answer from 1 to 5, where 1 is 'completely disagree' and 5 'completely agree'	Question with Likert Scale response (1-5).	Baldwin, Pickering, and Dale (2022), Kuthe et al. (2019)
Item 7. What do you think are the main causes of climate change? Mark with an X only one cause.	Closed response question: Do not know/No answer/ Human action / Pollution / Deforestation / The use of plastics / The overexploitation of resources / Natural causes / Others.	Kuthe et al. (2019), Busch et al. (2019).
Item 8. What do you think are the main consequences of climate change? Mark with an X only one consequence.	Closed response question: Do not know/No answer/ Increase in temperature / Increase in sea level / Melting / Increase in natural risks / More diseases / Extinction of species / None / Others.	Busch et al. (2019), Littrell et al. (2020).
Item 9. Could you indicate any effects of climate change that you have noticed?	Open answer question.	Baldwin, Pickering, and Dale (2022), Littrell et al. (2020), Kuthe et al. (2019).

Source: Own elaboration.