



## Article

# What Do School Children Know about Climate Change? A Social Sciences Approach

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**Abstract:** One of the subject areas that is currently most prominent in the field of education (Social Science) is climate change, given its implications for raising awareness and training the present and future society. The objectives of this study, focused on school children (Primary Education—10 to 12 years old; third cycle, Secondary Education—12–16 years old; and pre-university, Baccalaureate—17–18 years old) in the Region of Valencia (Spain), are to analyse the following: the main information channels through which children receive information on climate change; the causes and consequences that they identify with respect to this phenomenon; and the main greenhouse gas that they believe is in the atmosphere. Based on the 575 students surveyed during the academic year 2020–2021, the results indicate that the three main information media are digital (TV—82.8%, Internet—56.2% and social networks—49.4%). With respect to the causes of the phenomenon identified by the students, particularly noteworthy was pollution (70.1%) and, in terms of the effects, the increase and changes in temperature (61.7%) were of particular note. Finally, with reference to greenhouse gases, the majority responded CO<sub>2</sub> (63.5%). This is incorrect, as the main greenhouse gas in the atmosphere is water vapour. To sum up, we can highlight the role played by schools in training the future society and the risk arising from an increase in the information received from digital media by children as they grow older, due to the danger of misinformation.

**Keywords:** climate change; school; media; Social Sciences; Geography



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## 1. Introduction

One of the main challenges faced by the society of the twenty-first century is global warming, as expressed in the Sixth Report of the Intergovernmental Panel on Climate Change (IPCC 2022). This report highlights the importance of adapting to this phenomenon due to its effects, such as the increase in temperature, the loss of climate comfort or the intensification and greater frequency of extreme weather phenomena (floods and droughts). Therefore, raising awareness and rigorously teaching about climate change is in everyone's interest, but is of particular concern for the educational environment (Jeong et al. 2021; Masters 2020; Nelles and Serrer 2020; Verlie and Blom 2021), as, in part, the future of society depends on increasing our knowledge about this serious problem (Borhaug 2021; Ferrari et al. 2019; Kurup et al. 2021; Morote and Olcina 2021a). The latter authors consider that the challenge of addressing global warming and climate change in education (Social Sciences) should be focused on by including informed decision making in classroom practices.

Regarding the research problem addressed here (teaching and climate change), for decades, different authors (Benejam 1997; Fien 1992) have described the urgent need to discuss world problems in schools (including climate change issues) through the Didactics of Social Sciences, in its different scales. Furthermore, the content of climate change is among of the most controversial that must be explained in social science classes (Ho and

Seow 2015; Morote et al. 2021b). Thus, Benejam (1997) explains that “training our students as citizens of a democratic and alternative system” (p. 47) is necessary, among other purposes, “to preserve and value the natural and cultural heritage that we have received as legacy” (p. 48). As many authors affirm, this is based on the inclusion of Relevant Social Problems (RSP) in social science classrooms, a methodology that comes from the Anglo-Saxon sphere (Fien 1992; Evans et al. 1996). Although in Francophone literature, as López and Oller (2019) explain, the same approach is described, it is called Socially Alive Issues (SAI) (Legardez 2006; Legardez and Simonneaux 2006; Tutiaux-Guillón 2011). In Spain, this approach has also been incorporated from different research (Benejam 1997; García, Francisco, and Rafael Porlán 2000; García and Alba 2003; Pagès and Santisteban 2011; Pagès 2007; López 2011; Canals and González 2011; Santisteban et al. 2014; Díaz and Felices 2017).

With respect to the interest in teaching about climate change, some authors (Morote and Olcina 2020, 2021a; Rausell et al. 2021) have pointed out that education is one of the most important non-structural factors for adapting to and addressing this phenomenon. However, these researchers also indicate that it is one of the variables that is least frequently taken into account, with priority given to structural and political mitigation measures. The importance of climate change has also been indicated by different international bodies. In its Fifth Report (IPCC 2014), the IPCC pointed out that education was one of the main actions necessary for adapting societies to this phenomenon. In addition, the United Nations (UN 2015) identifies this variable “education” as one of the most important elements in mitigating the effects of climate change (Sustainable Development Goal n°13 “Climate action”). Similarly, the European Environmental Agency (EEA 2017) indicated the importance of the vulnerability factor, highlighting education as a way to mitigate the effects of global warming. This issue has also been a point of interest with respect to educational laws, on both an international and a national (Spain) level (Morote and Olcina 2021b). Hence, in Spain (the present study case), the Climate Change Act was published (May 2021), which, for the first time, included a section on teaching: Title VIII (“Education, Research and Innovation in the fight against climate change and energy transition”).

Initially, the issue of environmental and climate change constituted a controversial topic from a scientific point of view, as the extent to which human action altered the natural conditions of climate evolution was questioned (Ho and Seow 2015). Currently, the majority of researchers back these facts with evidence (Roussel and Cutter-Mackenzie-Knowles 2020) and it has now become a conceptual topic taught in the subjects of Geography and Social Sciences (Morote and Olcina 2020, 2021a). In Spain, explanations for climate change carry more weight in the educational setting due to the requirement to address these topics in classrooms, as established both for Primary Education (Royal Decree 126/2014, 28 February; Social Sciences subject) and Secondary Education and the Baccalaureate (Royal Decree 1105/2014, 26 December; Geography subject).

Another issue to consider with respect to the teaching of climate change is the influence that the media has on both teachers’ and students’ understanding of the issue (Morote et al. 2021a; Wu and Otsuka 2021). One of the consequences of this is the dissemination of fake news and stereotypes that have arisen in the social representation of the youngest cohorts (Ferrari et al. 2019). In fact, Morote et al. (2021a) have analysed how the information that the majority of trainee teachers receive is drawn from the Internet, television and social networks. Kažys (2018), Brisman (2018) and Lutzke et al. (2021) explain the danger that this could have in the case of information that is unreliable or lacks rigour, or when the news is false or manipulated. This fact (false information lacking in rigour) has even been transferred to the contents in Social Science textbooks, as confirmed by Morote and Olcina (2020), where there is: (1) a predominance of information with scientific errors; and (2) an excessive influence of the media and a catastrophic view of climate change. In the case of these resources (school textbooks), this problem is even more serious since, currently, in Social Sciences classes, they continue to be the main resource used (Bel et al. 2019). This is also reflected in the social attitudes of future teachers with respect to this phenomenon,

in which human action is viewed as the main cause and natural disasters its main effects (Morote 2020). As this author explains, it is true that the majority of trainee teachers have received training on this subject matter, but only 13.4% of this training is based on academic studies. Therefore, as indicated by Morote et al. (2021a), the information received is similar to that presented by the media (86.2%) and constitutes a superfluous approach to the phenomenon, which fosters the creation of stereotypes.

In Spain, there is a consolidated line of study related to the teaching of climate change in the educational sphere (Caride and Meira 2019; Escoz-Roldan et al. 2020) and also in the field of the natural sciences (Calixto 2015; Domènech 2014). However, the same cannot be said for Social Science and/or Geography. It is true that these sciences have produced extensive literature on the teaching of climatology (Martínez-Fernández and Olcina 2019; Morote and Moltó 2017; Sebastiá and Tonda 2018), but not on climate change, except for some recent publications. In this respect, over the last few years, recent studies have been carried out on the teaching of this phenomenon from three perspectives: (1) the social attitudes of trainee teachers (Morote and Hernández 2020; Morote and Moreno 2021; Morote et al. 2021a); (2) the analysis of the contents of school textbooks (Morote and Olcina 2020, 2021a); and (3) didactic proposals (Morote and Olcina 2021b). In fact, the former president of the Spanish Association of Geography expressed the need for a greater dedication and interest in this subject matter similar to that of other scientific fields and on the international scene (Olcina 2017). On an international level, many works have been published on the teaching of climate change, such as those in Central and North America (McWhirter and Shealy 2018; Li et al. 2021; Sezen-Barrie and Marbach-Ad 2021), South America (Da Rocha et al. 2020), Europe (Jeong et al. 2021; Kovacs et al. 2017; Kurup et al. 2021), Africa (Anyanwu and Grange 2017) and Asia and Oceania (Ahmad and Numan 2015; Li and Liu 2021; Verlie and Blom 2021).

The objectives of this research are to analyse the following, using a case study of Primary Education (10–12 years old; third cycle), Secondary Education (12–16 years old) and Baccalaureate (17–18 years old) students of the Region of Valencia (Spain): (1) the main information channels through which students receive information on climate change; (2) the causes and consequences of this phenomenon that are identified by the students and whether these involve differences between these three educational levels; and (3) the main greenhouse gas that students believe is present in the atmosphere. With respect to the starting hypothesis, it was believed that the students would claim to receive information about this phenomenon mainly through audio-visual media (TV, Internet, social networks). Regarding the causes, it was expected that the students would respond that they are related to human action (mainly pollution), while the effects cited by the students were expected to be the increase in temperature, sea level, glacier melting, etc. (second hypothesis). In terms of the main greenhouse gas present in the atmosphere, it was expected that the response of the majority of the students would be CO<sub>2</sub> (third hypothesis). Significant differences were expected to be found between the three educational stages. The cognitive age of the students, a priori, was expected to influence the answers (fourth hypothesis). For this reason, we would expect the responses of the Baccalaureate students to be more elaborate and self-critical and with fewer errors in their content (for example, in relation to greenhouse gases). This study, therefore, will help to reveal the social attitudes of school children with respect to climate change and whether their understanding coincides with that of their teachers and with the information that is printed in their school textbooks. These latter considerations are addressed in the Discussion section.

## 2. Methods

### 2.1. Design of the Research

This study is based on a correlational study (non-experimental). Regarding the type of didactic research, it is characterized by its presentation of a socio-critical approach (see López and Oller 2019). As numerous authors affirm (Benejam 1997; Díaz and Felices 2017), these works are based on the inclusion of Relevant Social Problems (RSP) in Social Science

classrooms. This methodology originated in the Anglo-Saxon sphere (Fien 1992; Evans et al. 1996; Ochoa 1996). It has also been developed in the Francophone literature, although it is called Socially Alive Issues (SAI) in this field (Legardez 2006; Legardez and Simonneaux 2006; Tutiaux-Guillón 2011). The research design is explanatory and transversal, as the information analysed was gathered at a specific moment (academic year of 2020–2021) and refers to a case study (eight public educational centres in the Region of Valencia, Spain): four centres of Primary Education and four centres of Secondary Education and Baccalaureate.

## 2.2. Context and Respondents

With regard to the context and the respondents, the selection procedure was conducted through non-probability sampling (availability or convenience sampling). The participants in this study were Primary Education students (third cycle; fifth and sixth; 10–12 years old), Secondary Education students (first and third; 12–16 years old) and Baccalaureate students (second year of Baccalaureate; 17–18 years old). The total number of students enrolled in these years was 605: Primary Education ( $n = 180$ ), Secondary Education ( $n = 300$ ) and Baccalaureate ( $n = 125$ ). With respect to the representativeness of the sample and taking into account the total number of students enrolled ( $n = 605$ ), a minimum of 318 students would be required to obtain a representative sample so as to achieve a confidence interval of 99% and a margin of error of 5%. Finally, since the total number of respondents was 575, a representative number was achieved (see Table 1). With respect to the socio-demographic characteristics (gender and age), the figures are similar from the point of view of gender: male (45.7%;  $n = 263$ ); female (53.7%;  $n = 309$ ). The average age in the whole sample was 13.8 years.

**Table 1.** Students who took part in the research.

Educational Stages	Enrolled ( $n$ )	Respondents ( $n$ )	Average Age	Gender
Primary Education	180	176	11.0	Male (55.7%; $n = 98$ ); Female (43.8%; $n = 77$ )
Secondary Education	300	285	13.4	Male (44.6%; $n = 127$ ); Female (55.1%; $n = 157$ )
Baccalaureate	125	114	17.2	Male (33.8%; $n = 38$ ); Female (65.8%; $n = 75$ )
<b>Total</b>	<b>605</b>	<b>575</b>	<b>13.8</b>	<b>Male (45.7%; <math>n = 263</math>); Female (53.7%; <math>n = 309</math>)</b>

Source: Survey results. Own elaboration.

## 2.3. Questionnaire

The instrument designed to carry out the research was based on a questionnaire to obtain the data needed to achieve the aims proposed. It was a questionnaire prepared expressly for this research, following the model of other works about social attitudes (see López and Oller 2019; Morote and Hernández 2020; Morote and Moreno 2021; Morote et al. 2021a, 2021b). In this study, this questionnaire was adapted to the non-university school stage (12-item questionnaire—see Appendix A). The questionnaire was also validated by three researchers from: the Department of Experimental and Social Sciences Education at the University of Valencia (Spain), the Department of Mathematics and Social Sciences Education at the University of Murcia (Spain) and the Department of Regional Geographic Analysis and Physical Geography of the University of Alicante (Spain). For this study (in accordance with the aims proposed), the results were obtained from parts 1 (Item 4) and 2 (Items 7, 8 and 9) (see Table 2).

**Table 2.** Items of the questionnaire used for this research.

<b>Part 1. Training on Climate Change</b>	
<b>Item (n°)</b>	<b>Response Type/Variable</b>
Item 4. Of the following information media, choose the top three where you receive information on climate change:	Closed-ended question: Do not know/Do not answer/Family/Social Networks/TV/Newspapers/Radio/Internet/School-High School
<b>Part 2. Perception of Climate Change</b>	
<b>Item (n°)</b>	<b>Response Type/Variable</b>
Item 7. What are the main causes of climate change?	Open question
Item 8. What are the main consequences of climate change?	Open question
Item 9. What is the main greenhouse gas in the atmosphere?	Closed-ended question: Do not know/Do not answer/Methane (CH <sub>4</sub> )/Ozone (O <sub>3</sub> )/Carbon Dioxide (CO <sub>2</sub> )/Water Vapour (H <sub>2</sub> O)/Nitrous Oxide (NO <sub>x</sub> )

Source: own elaboration.

Item 9, “What is the main greenhouse gas in the atmosphere?”, was included because most of the population is unaware that this is the main greenhouse gas. The prevailing idea, influenced by the media (Morote et al. 2021a) and also replicated in the school textbooks (Morote and Olcina 2020) is that the main greenhouse gas is CO<sub>2</sub>, which is incorrect.

In order to assess the construct validity of the questionnaire, several procedures were carried out. First, a statistical analysis of the ordinal variables (Items 11 and 12) 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 construct was subjected to the Kaiser–Meyer–Olkin (KMO) validity test, which indicates whether the factor analysis of the instrument is acceptable. The KMO test gave a positive result of 0.376, which, according to other factor reliability studies, is considered to be an acceptable level (Pérez-Gil et al. 2000). Third, being a mixed questionnaire (quantitative and qualitative), the Friedman chi-squared test (Friedman’s  $X^2$ ) was carried out. It generated a positive value of 303.067 ( $p = 0.001$ ), which indicated that there was no discrepancy between the variables. Therefore, the variables were dependent on one another (Satorra and Bentler 2010; Sharpe 2015). The results obtained through these procedures render the research reliable, as in the case of other studies on the teaching of Social Science (Moreno-Vera et al. 2020; Morote et al. 2021b).

#### 2.4. Procedure

The questionnaire was administered in a mid-term session (first four-month period) during the second semester (2021), with a response time of 10 minutes. It should also be noted that the questionnaire was administered prior to the teaching of sessions related to climate and natural hazards so as not to influence the answers (subject of Social Science and/or Geography). Finally, the respondents’ anonymity was preserved during the entire procedure and confidentiality was guaranteed in writing.

#### 2.5. Data Analysis

For the data analysis procedure, the program SPSS v26 (IBM, New York, NY, USA) was used to carry out a statistical–inferential analysis (non-parametric tests) of the frequencies and percentages. In the data analysis, the chi-squared test was carried out for the nominal variables (Items 4, 7, 8 and 9). Furthermore, the school stage and the opinions in the open responses (qualitative information) of Items 7 and 8 were coded (see Tables 3 and 4).

**Table 3.** Coding of answers to Item 7.

Response Type	Code
Do not know/Do not answer	0
Human factor	1
Pollution	2
Deforestation	3
Use of plastics	4
Overexploitation of resources	5
Natural causes	6
Mistakes	7

Source: own elaboration. Note: in “mistakes”, the answers in which the students confused “causes” with “consequences” were grouped.

**Table 4.** Coding of answers to Item 8.

Response Type	Code
Do not know/Do not answer	0
Temperature increase	1
Rising sea level	2
Melting	3
Increase of natural hazards	4
More diseases	5
Extinction of species	6
None	7
Mistakes	8

Source: own elaboration. Note: (1) for “temperature increase”, the responses related to sudden climate changes or in seasons, etc., were grouped together; (2) in “mistakes”, the answers in which the students confused “causes” with “consequences” were grouped.

### 3. Results

#### 3.1. Where Do School Children Receive Information about Climate Change from?

In the first item analysed (Item 4, “Of the following information media, choose the top three where you receive information on climate change”), the sources of information about climate global warming are examined. The overall data (a total of 1725 responses) reveal that the main media are digital (TV, Internet and social networks). Of the 575 participants, 82.8% ( $n = 475$ ) responded that they receive information from television, while 56.2% ( $n = 323$ ) responded that they receive information from the Internet and 49.4% ( $n = 284$ ) from social networks (Table 5).

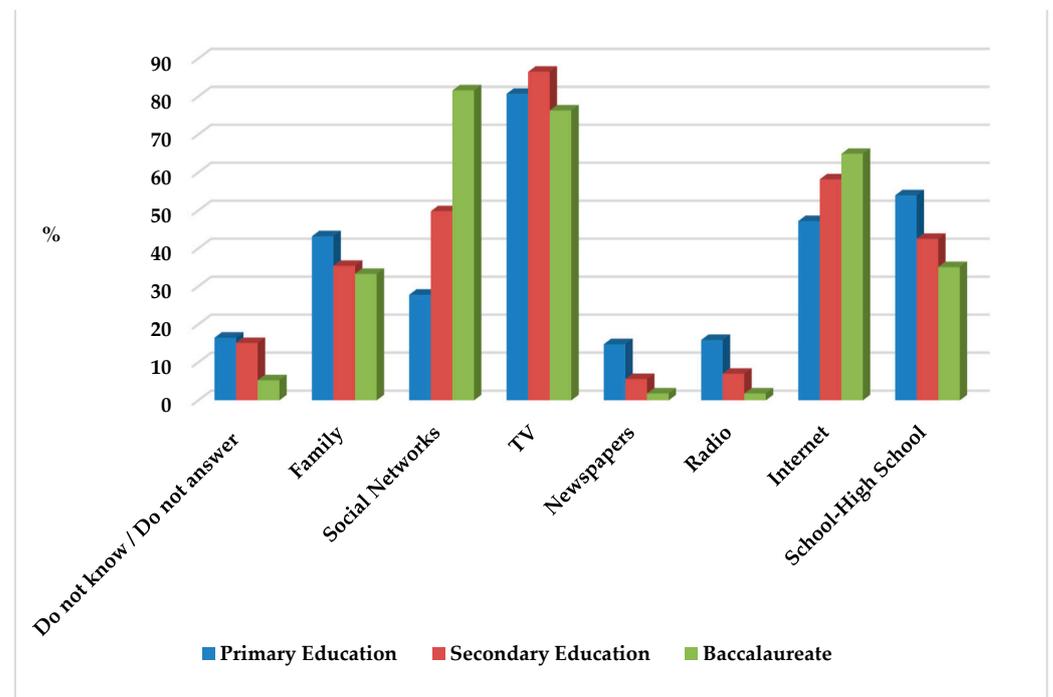
**Table 5.** Information media from where school students receive information on climate change (Item 4).

Information Media	<i>n</i>	%
Do not know/Do not answer	78	13.6
Family	215	37.4
Social Networks	284	49.4
TV	475	82.6
Newspapers	44	7.7
Radio	50	8.7
Internet	323	56.2
School–High School	256	44.5

Note: the % refers to the total number of respondents ( $n = 575$ ).

When analysing these media in accordance with the stage of education (Primary Education, Secondary Education and Baccalaureate), significant differences may be observed. With a total of 528 responses, the three main media for Primary Education students (10–12 years old) are: (1) TV (80.7%;  $n = 142$ ); (2) school (54.0%;  $n = 95$ ); and (3) Internet

(47.2%;  $n = 83$ ) (Figure 1). In Primary Education, the Chi-Squared test revealed that the association between these two variables (information media and schooling period) was significant (Pearson's Chi-Squared = 62.243;  $p = 0.001$ ). They were associated significantly ( $p < 0.05$ ), so they were dependent variables.



**Figure 1.** Channels of information through which the school children received information on climate change. Source: survey results. Own elaboration.

For the Secondary Education students (12–16 years old), with a total of 855 responses, the main media were: (1) TV (86.5%;  $n = 246$ ); (2) Internet (58.2%;  $n = 166$ ); and (3) social networks (49.8%;  $n = 142$ ) (see Figure 1). The Chi-Squared test reveals that the association between these two variables (information media and schooling period) is significant (Pearson's Chi-Squared = 50.976;  $p = 0.001$ ). There was a significant association between them ( $p < 0.05$ ), so they were dependent variables.

With respect to the Baccalaureate students (17–18 years old), with a total of 342 responses, the main media were: (1) social networks (81.6%;  $n = 93$ ); (2) TV (76.3%;  $n = 87$ ); and (3) Internet (64.1%;  $n = 74$ ). For this educational stage, the Chi-Squared test revealed that the association between these two variables (information media and school period) was significant (Pearson's Chi-Squared = 44.390;  $p = 0.001$ ). Since they were associated significantly ( $p < 0.05$ ), they were dependent variables.

The differences (in percentages) in the information sources used depending on the educational stage reveal that, as students progresses through the educational process, information from social networks and the Internet gain more relevance compared with the information received from school (Figure 1). In this respect, the response “school centre” is only relevant in the Primary Education stage. The responses related to schools fell from 54.0% (second position) in Primary Education to 42.5% (fourth position) in secondary education and to 35.1% among Baccalaureate students (fourth position). Meanwhile, social networks increased in relevance from 27.8% in Primary Education to 49.8% in Secondary Education and 81.6% in Baccalaureate. A similar trend can be observed for the responses related to the Internet: in Primary Education it represented 47.2% as opposed to 64.9% in the Baccalaureate. It should also be noted that Primary Education was the stage when the “family” variable had the greatest relevance (43.2%).

### 3.2. What Are the Causes and Consequences of Climate Change Identified by the Students?

Second, the causes (Item 7) and consequences (Item 8) of climate change according to the opinion of the school children were analysed. This serves to establish relationships between what they know and perceive about this phenomenon. With respect to the causes, if we take into account the overall data (575 responses), the results revealed that the main cause of this phenomenon was perceived thought to be pollution (70.1%;  $n = 403$ ) (see Table 6) and, second, “no responses” (9.9%;  $n = 57$ ). The Chi-Squared test revealed that the association between these two variables (causes and school period) was significant (Pearson’s Chi-Squared = 48.516;  $p = 0.001$ ). Since the association between them was significant ( $p < 0.05$ ), they were dependent variables.

**Table 6.** “What are the main causes of climate change?” (Item 7).

Educational Stage		0	1	2	3	4	5	6	7	Total
Primary Education	<i>n</i>	24	4	108	6	11	1	9	13	176
	%	13.6%	2.3%	61.4%	3.4%	6.3%	0.6%	5.1%	7.4%	100.0%
Secondary Education	<i>n</i>	28	13	205	3	8	1	6	21	285
	%	9.8%	4.6%	71.9%	1.1%	2.8%	0.4%	2.1%	7.4%	100.0%
Baccalaureate	<i>n</i>	5	15	90	1	2	0	1	0	114
	%	4.4%	13.2%	78.9%	0.9%	1.8%	0.0%	0.9%	0.0%	100.0%
<b>Total</b>	<i>n</i>	<b>57</b>	<b>32</b>	<b>403</b>	<b>10</b>	<b>21</b>	<b>2</b>	<b>16</b>	<b>34</b>	<b>575</b>
	%	<b>9.9%</b>	<b>5.6%</b>	<b>70.1%</b>	<b>1.7%</b>	<b>3.7%</b>	<b>0.3%</b>	<b>2.8%</b>	<b>5.9%</b>	<b>100.0%</b>

Source: survey results. Own elaboration. Note: Do not know/Do not answer (0)/Human factor (1)/Pollution (2)/Deforestation (3)/Use of plastics (4)/Overexploitation of resources (5)/Natural causes (6)/Mistakes (7).

When these data were analysed in accordance with the educational stages, it was observed that the percentage for the item “pollution” increased as the age of the students increased, while that of “no responses” decreased. Some of the responses of the students on these causes (“pollution”) were: “car pollution” (student n°57 in Primary Education); “fuel, smoke, rubbish” (student n°65 in Secondary Education); and “excessive use of transport” (student n°14 in Baccalaureate). Another distinctive factor was that, in the case of the Baccalaureate students, the second category of responses was related to “human action” (13.2%;  $n = 15$ ) as: “consumerism” (student n°1 in Baccalaureate); “lack of awareness” (student n°68 in Baccalaureate); “low level of social awareness” (student n°104 in Baccalaureate). These responses were related to a greater sense of responsibility and a more critical perspective of the impact of society on the environment.

With respect to the consequences, if the overall data are considered (575 responses), the participants indicated that the main effects of climate change were the increase and changes in temperature (61.7%;  $n = 355$ ) (see Table 7). The Chi-Squared test revealed that the association between these two variables (effects and school period) was significant (Pearson’s Chi-Squared = 55.004;  $p = 0.001$ ). Since the association between them was significant ( $p < 0.05$ ), they were dependent variables. Similarly to the causes, the item “Nr/Dk” appeared (11.5%;  $n = 66$ ). This percentage decreased as the age of the students increased and there was an increase in the percentage of responses related to the increase in temperature (in Secondary Education) and “melting” (in Baccalaureate). Among the Primary Education students, these factors represented 50.0% ( $n = 88$ ), as opposed to the 63.9% ( $n = 182$ ) in Secondary Education and 74.6% ( $n = 85$ ) in Baccalaureate. Some of the opinions on temperatures were: “it is getting increasingly hotter; in Alicante, in winter, it is practically spring” (student n°2 in Primary Education); “it is 30° in winter” (student n°163 in Primary Education); “in winter it is warmer than before” (student n°176 in Primary Education); “in summer, sometimes it can get cold and in winter hot” (student n°74 in secondary education); “in summer the temperatures go above 40°” (student n°96 in secondary education); “the weather is crazy (student n°132 in Secondary Education); “strange temperatures” (student n°243 in Secondary Education); “the temperatures vary a

lot from one day to the next” (student n°33 in Bacculaureate); “there is hardly a spring or autumn any more” (student n°80 in Bacculaureate).

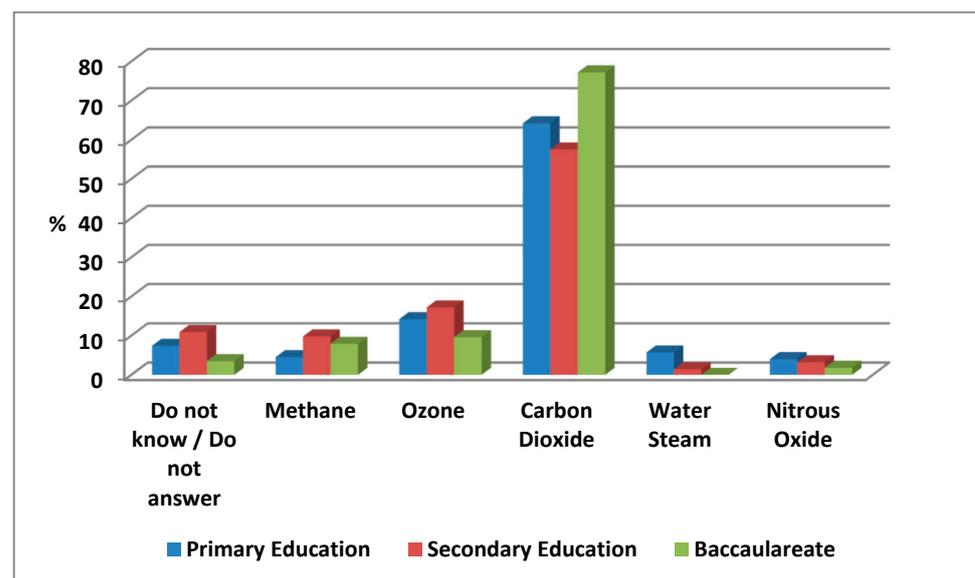
**Table 7.** “What are the main consequences of climate change?” (Item 8).

Educational Stages		0	1	2	3	4	5	6	7	8	Total
Primary Education	<i>n</i>	25	88	7	9	16	3	2	7	19	176
	%	14.2%	50.0%	4.0%	5.1%	9.1%	1.7%	1.1%	4.0%	10.8%	100.0%
Secondary Education	<i>n</i>	37	182	7	24	14	2	4	3	12	285
	%	13.0%	63.9%	2.5%	8.4%	4.9%	0.7%	1.4%	1.1%	4.2%	100.0%
Bacculaureate	<i>n</i>	4	85	2	17	2	0	2	0	2	114
	%	3.5%	74.6%	1.8%	14.9%	1.8%	0.0%	1.8%	0.0%	1.8%	100.0%
Total	<i>n</i>	66	355	16	50	32	5	8	10	33	575
	%	11.5%	61.7%	2.8%	8.7%	5.6%	0.9%	1.4%	1.7%	5.8%	100.0%

Source: survey results. Own elaboration. Note: Do not know/Do not answer (0)/Temperature increase (1)/Rising sea level (2)/Melting (3)/Increase of natural hazards (4)/More diseases (5)/Extinction of species (6)/None (7)/Mistakes (8).

### 3.3. What Is the Main Greenhouse Gas in the Atmosphere, According to the Students?

Third, Item 9 (“What is the main greenhouse gas in the atmosphere?”) was analysed. The overall results obtained indicate that the majority of the responses were related to carbon dioxide (CO<sub>2</sub>) (63.5%; *n* = 365) and, second, albeit with considerably lower figures, the ozone (O<sub>3</sub>) (14.8%; *n* = 85) (Figure 2). The Chi-Squared test revealed that the association between these two variables (greenhouse gases and school period) was significant (Pearson’s Chi-Squared= 30.354; *p* = 0.001). Since the association between them was significant (*p* < 0.05), they were dependent variables.



**Figure 2.** “What is the main greenhouse gas in the atmosphere?” (Item 9). Source: survey results. Own elaboration.

These data were directly related to the causes identified as “pollution” and were, therefore, expected. However, it should be noted that the majority of the students did not respond correctly. The question in Item 9 is related to the main greenhouse gas in the atmosphere (the correct answer is water vapour). This is different from asking about “the main greenhouse gas that is accelerating the climate change process due to anthropic causes” (the correct answer would be carbon dioxide). The correct response would be water vapour, which represents 4% of greenhouse gases, as opposed to CO<sub>2</sub>, which accounts

for 0.04%. This is important to point out as we expected that as the children progressed through the educational stages, the correct response would be higher. However, this was not the case, as no students in the Baccalaureate stage marked water vapour. By contrast, the Primary Education students (although the data were still low with respect to the main answer) are those who gave the highest percentage of correct answers (water vapour), 5.7% ( $n = 10$ ) (see Figure 2). Moreover, a relationship could be established between the responses obtained and the information received from the information media. In this respect, we can confirm that a higher percentage of the students who received more information from school responded correctly to this question. Nevertheless, overall, the data are worrying, due to the low percentage of correct answers in all of the educational stages.

#### 4. Discussion

The results obtained in this study highlight the importance that social networks and digital media acquire as the ages of students increase with respect to information on climate change. The first hypothesis established that “students receive information about this phenomenon mainly through audio-visual media (TV, Internet, social networks)”. With respect to the media, this hypothesis was fulfilled. The response regarding “school centre” is only relevant in the Primary Education stage. In this respect, the responses related to school centres decreased from 54.0% in the primary stage to 42.5% in Secondary Education and to 35.1% in Baccalaureate. Meanwhile, social networks increased in relevance from 27.8% in Primary Education to 49.8% in Secondary Education and 81.6% in Baccalaureate. A similar trend can be observed for the responses related to the Internet: in Primary Education, it represented 47.2%, as opposed to 64.9% in Baccalaureate. Therefore, as students progress through the educational stages, the school centre loses its relevance and digital media gains in influence (TV, Internet and social networks), which entails risk.

Taking into account these results, we should ask whether the data obtained in this study coincide with the understanding of trainee teachers and the contents of school textbooks (the main resource used in Social Science classrooms) (Bel et al. 2019). For example, in the study by Morote (2020), the data indicated that future Primary Education teachers receive this information mainly from digital media (68.2%), distributed as follows: social networks (28.7%), television (23.1%) and Internet (16.2%). The responses related to academic studies (university training) accounted for only 13.4%. Furthermore, according to Morote et al. (2021a), 86.2% of the information about climate change received by Primary Education trainee teachers is derived from the media. In another study on Secondary Education and Baccalaureate teachers (comparing University of Valencia, UV and Murcia, UMU, Spain), the percentages of information received from digital media were 67.7% (UV) and 54.2% (UMU) (Morote and Moreno 2021). Furthermore, in Chile (University of Concepción), a predominance of the media (52.0%) was found in the social attitudes of students in three different academic fields (science and mathematics, biology and social education) (Parra et al. 2013).

Therefore, the training of future teachers is based on digital media, which leads to a low level of development in generic and transversal competencies in these topics, as acknowledged by Parra et al. (2013). Other authors also indicate the risk that could ensue if the majority of this information is drawn from media, characterised by the consumption of untruthful information that sometimes lacks scientific rigour and is overly sensationalist (Allen et al. 2018; Brisman 2018; Kažys 2018; Lutzke et al. 2021). Morote (2020) explains that the media also provide truthful information, although the majority report information that lacks rigour in order to attract audiences, using false news and/or apocalyptic headlines. This author has also researched the perceptions of this type of news by trainee teachers. The results reveal that 56.2% agree that this type of news has a manipulative objective and/or presents false information: “highly agree” (25.3%) and “agree” (30.9%). However, there is a high percentage of participants who are “indifferent” to this type of news (29.5%). Other studies have also found that the training of active teachers is deficient. A study carried out by Gallego and Castro (2020) among university lecturers (Colombia) to identify the

understanding acquired in the teacher training process regarding climate change reveals that there are gaps in this training. Specifically, trainee teachers have a vague idea about the scientific model of climate change and their preparation in this area is the fruit of the popularisation of the topic, which, in many cases, is obtained from television programmes and websites. Therefore, they contribute to the transmission of implicit theories of climate change and, moreover, conceptual errors which, due to their role as teachers, will be transmitted to the future generations.

This deficient training may lead teachers to use school textbooks excessively (Morote and Souto 2020). This has been confirmed in subjects characterised by activities based on memorisation and the reproduction of content at a low cognitive level, as in the case of Geography (Kidman 2018). Furthermore, this teaching resource also lacks scientific rigour (Morote and Olcina 2020). This could mean that this topic is not taught in the classroom or is taught very loosely (Olcina 2017). In relation to climate change, the most common mistakes include the almost complete absence of discussion of the human influence (vulnerability) when referring, for example, to natural hazards (Morote and Olcina 2020). This is fundamental, as acknowledged in different reports on the effects of climate change (IPCC 2022), since it is necessary to address the vulnerability factor to adapt to this phenomenon (EEA 2017).

The second hypothesis (causes: “it is expected that the students will respond that they are related to human action –mainly pollution –”; consequences: “would be the increase in temperature, sea level, glacier melting, etc.”), was confirmed. The results revealed that the phenomenon of climate change is seen by students as an issue of “pollution” and an “increase in temperatures”. Furthermore, we observed that these responses became more important as the children grew older. This may have been due to the greater influence of digital information media (Internet, social networks, and TV) as the age of the students increased. In these media, there is a predominance of news identifying pollution as the cause and the increase in temperature as the effect.

Different studies carried out from the social attitudes of trainee teachers generated results similar to those of this study. For the case of Secondary Education teachers, Morote and Moreno (2021) indicate that the causes identified are human action (pollution, deforestation, and overexploitation of resources) and that the consequences are related to catastrophic effects (natural disasters). A similar result was obtained by Escoz-Roldan et al. (2020), who analysed the social attitudes of undergraduate students with respect to the risk of climate change and its relationship with water in three Spanish cities. In total, 85.0% of the respondents believed that climate change was “mainly due to human causes”. Furthermore, the study conducted in two secondary schools in the United Kingdom by Kurup et al. (2021) revealed a strong understanding of the causes and effects of global warming. This was corroborated, in turn, by Chang and Pascua (2016) for Asia, who found that students’ understanding of the causes of climate change was limited to the belief that the recorded changes are solely due to anthropogenic reasons. Gaps in training in terms of content can also be observed in students’ difficulty in establishing relationships between the different elements and processes that intervene in the climate change process beyond associating them with processes that they consider to be “good” or “bad”. In other words, they also lack the specific vocabulary to explain these processes. Furthermore, Wu and Otsuka (2021) found that, based on a sample of 657 Secondary Education students in Shanghai (China), erroneous concepts and a biased comprehension of climate change persist. The authors highlight the need to expand climate literacy and education from a conceptual and geographical perspective. If we compare this study with other works, the students always maintain the same discourse pattern: the greenhouse effect is harmful for society, it is caused by human action and global warming has disastrous effects (Da Silva and Boveloni 2009).

These gaps are associated both with the sources from which the information is obtained (the media) and the school textbooks, in which there is a predominance of catastrophic messages and, often, images taken out of context (Morote and Olcina 2020). Although this

lack of scientific rigour is the dominant feature, it should also be noted that publications are emerging that address the current process of climate change simply and rigorously. An example is the study by [Nelles and Serrer \(2020\)](#) which, with abundant and clear graphic material, explains the different elements that comprise this complex process affecting the entire environment (the earth's climate, climate change, oceans, extreme events, ecosystems and human beings). [Scharmacher-Schreiber and Stephanie \(2020\)](#), using a question-answer method (is the climate becoming warmer and warmer? Can a difference of one degree be felt?), have elaborated materials on climate change directed at basic educational levels.

Furthermore, in the training on natural risks as effects of climate change, it is important to focus on how these processes are perceived by children. As indicated by [Zhong et al. \(2021\)](#), in a study on disaster education and its impact on children's perceptions of flooding in China, this enables us to explore its impact effectiveness and pathways. In turn, this furthers knowledge of the management of the consequences (effects) of climate change. In other words, it is important to know the effects of climate change and, using this knowledge, to implement actions aimed at managing these risks and to learn how society adapts through education, based on social representations and the perceptions of students.

The third hypothesis was also confirmed: with respect to the main greenhouse gas in the atmosphere, "it is expected that the response of the majority of the students will be CO<sub>2</sub>". The results generated from analysing the sources from which the children obtained their information on climate change or their causes and consequences were reiterated. [Chang and Pascua \(2016\)](#), through semi-structured interviews with secondary students from Singapore, found "that the students' knowledge of climate change is composed of incomplete and incorrect elements" (p. 84). This was corroborated by analysing the role played by gases in the greenhouse effect. For example, the students considered that CFCs are the major greenhouse gases (19.7%); 6.6% even believed that "climate change is linked with tectonic activities (tsunami, earthquakes)". Both of these assertions are incorrect. In the first case, this was because water vapour was not taken into account; there were even students who did not consider it as an element that affects climate change. Furthermore, an even more serious mistake was relating geological processes with atmospheric processes, as [Olcina \(2017\)](#) has observed in Secondary Education textbooks.

This conceptual confusion coincides with the results obtained in this study, where water vapour was an "unknown" element for the respondents. These results are similar to those obtained from analysing the contents of textbooks. For example, the aforementioned study by [Morote and Olcina \(2020\)](#) confirms that only three out of every ten books refer to water vapour as a greenhouse gas. However, none of the textbooks indicate that it is the principal greenhouse gas in the atmosphere. Nevertheless, this fact, as expressed by the authors, is not completely negative, as 33.3% of textbooks at least mention it. Moreover, it should be explained that CO<sub>2</sub> is the main greenhouse gas that is increasing due to anthropic reasons (0.04%), but its presence in the atmosphere continues to be much lower than that of water vapour (4.0%).

The fourth hypothesis established that "significant differences are expected to be found between the three educational stages. The cognitive age of the students, a priori, should influence the answers. For this reason, we would expect the responses of the Baccalaureate students to be more elaborate, self-critical and with less error in their content (for example, in relation to the greenhouse gases)". This was partially confirmed. We can confirm that as the age of the students increased, the number of errors related to their responses on greenhouse gases also rose. In the case of the Baccalaureate stage, none of the students responded correctly. Again, the influence of the media could be the cause of this error.

Teaching the topic of climate change based on a holistic and integrated approach would constitute an opportunity to promote critical thought in society and among citizens. Only in this way will the current and future society be able to interpret its surrounding territory. In this respect, we can refer to the initiative in the United Kingdom that has recently incorporated teachers specialising in climate change into primary and secondary education centres ([Ecoinventos 2019](#)). Furthermore, it is also worth highlighting case study analyses

that examine studies on natural risks (Aspin 2018), such as global warming (Greenwood 2018), carried out for several decades by the Geographical Association (United Kingdom) in Primary Education. The acquisition of the competencies required to face challenges in the future should be one of the objectives of future teachers. This will enable them to understand people's perspectives, social processes and human–environment interactions and to connect local and global geographical concepts. These concepts include climate change in terms of space, place, scale, physical and human processes, environmental and cultural diversity and interdependence (Chang and Wi 2018). This would enable future teachers to educate a new generation of critical thinkers about climate change, supported by a good curriculum (Kagawa and Selby 2012).

## 5. Conclusions

The research carried out revealed that school children mainly obtain their information from digital media (TV, Internet, and social networks). One element that is particularly noteworthy is the relevance of schools in these contents: it was found that as the students progressed through the educational stages, the information received from their schools become less relevant compared with information from the media. This is a risk for the critical-thinking training of citizens, due to the need to confirm information and news from false sources, or news that lacks scientific rigour (Lutzke et al. 2021). Therefore, there is a risk that students take this information to be reliable. Furthermore, it is worth mentioning the work being carried out from the earliest educational stages (particularly primary education) in many schools and the importance given to “family” by these students. However, the relevance of digital media is also significant in very early ages (TV and Internet).

This research goes a step further and, taking into account previous studies, highlights that this knowledge on climate change is shared by trainee teachers and even the content included in school textbooks. Therefore, we are faced with a vicious circle, as the teacher has gaps in his or her training that are passed on to the student who, in turn, will do the same in the future. Taking these training deficiencies and the need to break this vicious circle into account, future research needs to continue using surveys, but also, in particular, to analyse what is really taught in classrooms. The main limitation of this study is that what and how teachers teach climate change in Social Science classes was not analysed. This constitutes a challenge for future research. To achieve this, it is necessary to interview active teachers. In this way, the whole of the educational sphere will be completed, including schools, training at university level and even the resources used in the classroom which, in the case of Social Sciences, continues to be predominant.

As educators, we should underline the importance of raising awareness among the youngest cohort about climate change. Undoubtedly, the education factor is one of the most important pillars for the present and future adaptation to this phenomenon and its associated risks. The accurate communication of climate change to society is a key element in mitigation and adaptation policies and, as argued by Romero and Olcina (2021), “the academic world and the public powers must continue transferring the greatest amount of information possible based on proven facts” (p. 329). Therefore, teacher training should be improved with: (1) an explanation of the main issues in climate change, based on information and data provided by different scientific studies and comparing it with, for example, news stories that appear in the media or even the information provided by school textbooks; and (2) the fostering of “IOL” proposals (“Imagination + Originality + Local”) (Morote and Olcina 2021a). An improvement in training is required as teaching is a huge responsibility. Finally, there is a need, each day, to reinforce concepts that students find difficult to understand. Educators must be committed to implementing methodologies that continuously enhance teaching practices in order to ensure a sound geographical education, generating critically thinking citizens who know how to interpret the environment in which they live.

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## Appendix A

**Table A1.** Items of the questionnaire.

General Information	
Item (n°)	Response Type/Variable
Item 1. What course are you studying?	Open question.
Item 2. How old are you?	Open question.
Item 3. Gender	Closed-ended question: Male/Female/Other
Part 1. Training on Climate Change	
Item (n°)	Response Type/Variable
Item 4. Of the following information media, choose the top three where you receive information on climate change:	Closed-ended question: Do not know/Do not answer/Family/Social Networks/TV/Newspapers/Radio/Internet/School-High School
Item 5. What is climate change?	Open question
Part 2. Perception of Climate Change	
Item (n°)	Response Type/Variable
Item 6. Do you think that climate is changing? (mark with an X). Answer from 1 to 5, with 1 being least agree and 5 being most agree:	Likert scale: 1/2/3/4/5
Item 7. What are the main causes of climate change?	Open question
Item 8. What are the main consequences of climate change?	Open question
Item 9. What is the main greenhouse gas in the atmosphere?	Closed-ended question: Do not know/Do not answer/Methane (CH <sub>4</sub> )/Ozone (O <sub>3</sub> )/Carbon Dioxide (CO <sub>2</sub> )/Water Vapour (H <sub>2</sub> O)/Nitrous Oxide (NO <sub>x</sub> )
Part 3. Solutions and Proposals for Adapting to Global Warming	
Item (n°)	Response Type/Variable
Item 10. What do you do in your daily life to solve climate change?	Open question.
Item 11. Will climate change a problem for humanity in the future? (mark with an X). Please answer from 1 to 5, with 1 being less agree and 5 being more agree.	Likert scale: 1/2/3/4/5
Item 12. Will climate change pose a problem for humanity in the future? (mark with an X). Please answer from 1 to 5, with 1 being less agree and 5 being more agree.	Likert scale: 1/2/3/4/5

Source: Own elaboration.

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