



## Article

# Climate Change and Extreme Weather Events in the Education of the Citizens of the Twenty-First Century: The Perception of Secondary Education Students

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**Abstract:** Within the current context of climate emergency, the topic of climate change has become more prominent in secondary education in Spain. However, in general, conceptual confusions arise which should be clarified due to the social importance of climate issues. The objectives of this study, focused on third and fourth year students of ESO (Obligatory Secondary Education) in state schools in a town in the province of Alicante (Region of Valencia, Spain), seek to reveal the perception of the students regarding climate change and extreme weather events, in accordance with the subject in which these contents are taught; and to analyse whether the students have acquired a basic knowledge of the topic at the end of their secondary education. In order to fulfil these objectives, a non-experimental, descriptive, cross-sectional and survey-based correlational study has been conducted. The sample was made up of 784 students, surveyed during the academic year 2021–2022. The results indicate that the principal subject in which climate change is taught is Geography and History. The students consider that climate change is a threat to human beings and believe that anthropogenic action is the principal cause. They also perceive an increase in extreme weather events, although it is necessary to qualify this aspect. Therefore, this study defends the need to address this topic in the third and fourth years of ESO, as it is one of the major challenges faced by society and one in which students should be educated within the framework of the 2030 Agenda and the Sustainable Development Goals (SDGs).

**Keywords:** climate change; natural risks; Obligatory Secondary Education; 2030 Agenda; SDGs

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## 1. Introduction

Geography is the most suitable scientific discipline for teaching climate change. It combines the knowledge and interpretation of natural and human factors that intervene in the territory, offering a causal explanation of the processes occurring within it and the effects on the space and society, while contributing mitigation and adaptation actions. Since the end of the nineteenth century, the Spanish education system has incorporated contents on weather and climate in different study plans (Tonda-Monllor and Sebastián-Alcaraz 2003). It has constituted one of the branches of Geography of greatest interest in the academic world in recent years due to its growing social prominence as a result of its importance for understanding the current climate crisis. Climate experts indicate that teaching about climate change is a complex task (Olcina Cantos 2017), as it requires a broad knowledge of climate and the weather system, which is necessary for analysing

climate variables and the influence of geographic factors and for adopting measures to address the new environmental realities (Martín Vide 2009).

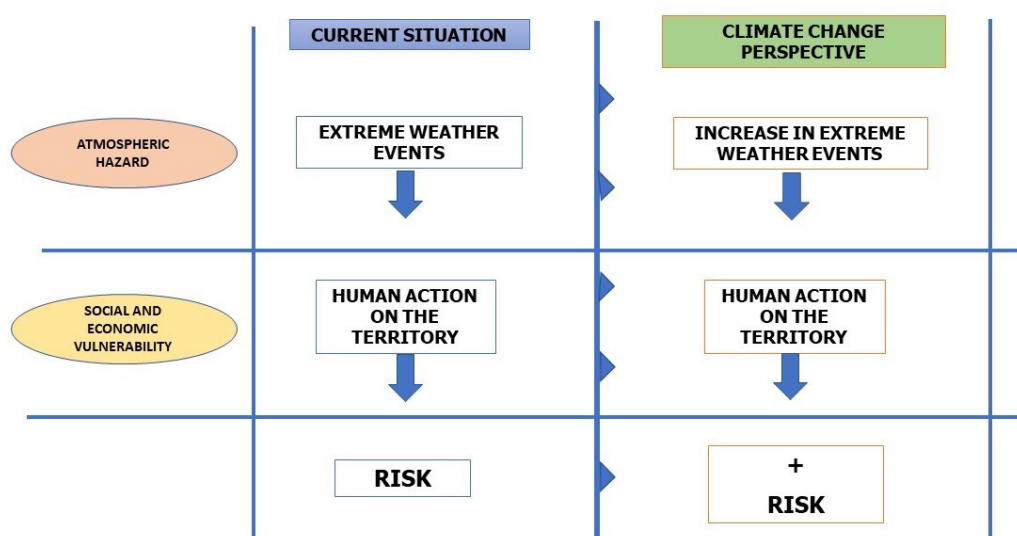
Currently, climate change is one of the most important challenges faced by humankind. Therefore, it is important that the teaching-learning process is conducted with scientific rigour and based on the principal source of information on climate change, the Intergovernmental Panel on Climate Change (IPCC). Since 1990, the IPCC reports have shown the current state of climate and the effects of climate change, both on nature and society. Furthermore, this organisation has proposed a series of measures to limit global warming and to adapt and mitigate the effects of climate change. All of these measures include education as a fundamental piece for raising awareness in society, among all age groups, through the dissemination of data and rigorous scientific information, without recurring to extremist, alarmist and catastrophic messages. Title 8 of Law 7/2021 of 20 May on climate change and energy transition, “Education, Research and Innovation in the fight against climate change and energy transition”, addresses the importance of education to ensure the involvement of Spanish society in the responses to climate change and in training for sustainable development and climate care (Jefatura del Estado 2021, p. 62041).

The greater presence of this topic in the Spanish Geography and History curriculum of Spanish teenagers (ESO and Baccalaureate) is particularly important due to the current climate change context, in which the increase in global warming (IPCC 2018) caused by human action is leading to an increase in extreme weather events (IPCC 2022). One of the greatest impacts in the Region of Valencia is the change in precipitation patterns, with an increase in torrential rains and the hourly intensity of the events (Moutahir et al. 2014; Olcina Cantos and Vera-Rebollo 2016; Serrano-Notivoli et al. 2018). It is vitally important to establish a new horizon in the teaching-learning process in order to fulfil Objective 13 of climate action within the 2030 agenda in order to meet the Sustainable Development Goals (hereafter, SDGs) (United Nations General Assembly 2015).

This topic has become increasingly relevant in recent years, with the ever-more visible effects of climate change. In view of the present scenario, the political arena has increased its efforts to improve the teaching of climate change and the Sustainable Development Goals (SDGs). This increased interest in studying this issue in the educational domain is due to several reasons. One is that this topic forms part of the geographic content included in the Social Sciences curriculum: Geography at Obligatory Secondary Education and Baccalaureate levels, included in Royal Decree 217/2022 of 29 March (Ministerio de Educación y Formación Profesional 2022). The new Organic Law 3/2020 of 29 December on Education (LOMLOE) incorporates substantial changes related to how to teach contents relating to the environment and natural catastrophes in secondary classrooms (Jefatura del Estado 2020). Among these changes, the law underlines the need to promote a competency-based, autonomous, significant and reflexive learning in all subjects. In this respect, the LOMLOE indicates as “basic knowledge” in the subject of Geography and History, included in Block A: Current global challenges for the 1st and 2nd years of ESO the study of: “The climate emergency: elements and factors that condition climate and the impact of human activities. [...] Climate risks and catastrophes in the present, past and future. Vulnerability, prevention and resilience of the population to natural catastrophes and the effects of climate change” (Ministerio de Educación y Formación Profesional 2022, pp. 41683–6484). Similarly, for the third and fourth years of ESO, the “basic knowledge” included in Block A refers to: Current global challenges are focused on: “Sustainable Development Goals. Climate emergency and sustainability. Relationship between natural and anthropogenic factors on Earth” (Ministerio de Educación y Formación Profesional 2022, p. 41688) and in Block C: Local and global civil commitment: “Involvement in the defence and protection of the environment. Action and position with respect to the climate emergency” (Ministerio de Educación y Formación Profesional 2022, p. 41689).

The area of study of this research, the Spanish Mediterranean coast bathed by the Mediterranean, has become a high-risk region, due to its weather conditions and the current context of climate change and also due to the increase in urbanisation and occupation

of floodable areas (Pérez-Morales et al. 2022). For these two reasons, it has become a study area for citizens of the twenty-first century, where it is necessary to educate society to raise awareness with respect to climate change with tangible effects through more frequent and intense extreme weather events that are affecting the Spanish Mediterranean (Sánchez-Almodóvar et al. 2022b). The current process of global warming increases the risk that already exists in this territory due to the increase in extreme weather events predicted by the climate models (Figure 1). In this respect, education has become a corner stone for raising awareness about and training in the causes and actions to implement to combat these extreme events, which generate considerable economic damage and the loss of human lives.

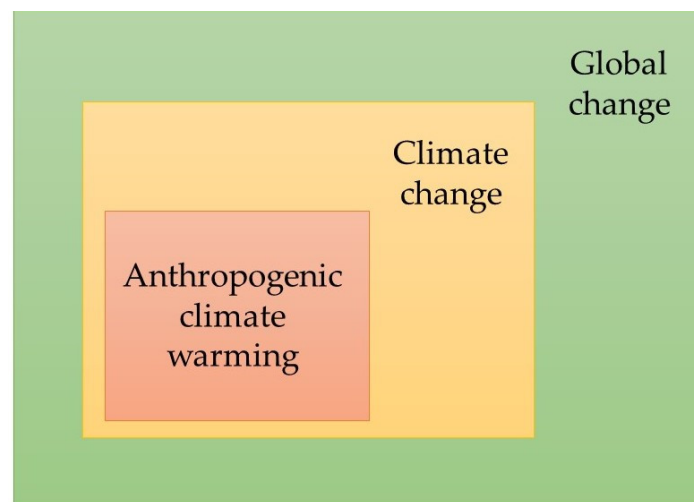


**Figure 1.** Societies at risk in the current context of global warming. Source: Own elaboration.

Within this context, education, sensitising and information and awareness-raising campaigns in society regarding the natural risks that exist in a territory constitute a fundamental pillar for the adaptation and mitigation of extreme natural events resulting from climate change and its effects. The science of geography seeks to educate critical citizens with a holistic view of the climate crisis which enables them to rigorously analyse its causes and consequences, an essential objective to create a more resilient society which is prepared to face this challenge.

### 1.1. Theoretical Framework

Before addressing the issue of climate change in the classroom, it is necessary to establish a conceptual corpus with which to facilitate the understanding and good practice in the most technical concepts which are usually used as synonyms, giving rise to errors. According to Martín Vide (2009), the concepts related to climate change (Figure 2), which are often treated as synonyms are: (1) global warming is the increase in the average temperature of the earth's surface, partly due to anthropogenic action. (2) Climate change includes human caused global warming, with the increase in the average temperature of the earth, the variation of precipitations and the retreat of the glaciers. Article 1.2 of the United Nations Framework Convention on Climate Change defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (Naciones Unidas 1992, p. 9). (3) Global change is a broader concept that covers all phenomena that involve changes on a global scale, such as climate change, the loss of biodiversity, changes in land use, etc.



**Figure 2.** Outline of the concepts used in climate change. Source: modification of Martín-Vide 2009, 64.

### 1.2. The State of the Question

The geography discipline plays a highly important role in the teaching of climate change, as, in order to understand this concept, it is necessary to know the territory, its physical and human characteristics and the interaction between the two. As indicated by Morote Seguido and Moltó Mantero (2017), geographic science should seek to ensure that through their training, students can acquire the competencies to allow them to understand, analyse and interpret the space in which they live and the most relevant events taking place within it.

On an international level, recent studies have been published that address the perception of climate change and natural risks. In China, the perception of flood risk among primary school children has been analysed (Zhong et al. 2021), and in Canada, the individual knowledge of secondary education students has been assessed regarding their actions to mitigate climate change (Pickering et al. 2020). In the United Kingdom, Kurup et al. (2021) analyse how the conception about global warming and climate change alters among secondary education students, before and after a class on the topic. Jamelske et al. (2013) conduct a study comparing the perceptions of climate change among American and Chinese university students. For Taiwan, the opinions of higher education students with respect to the challenge of climate change are examined (Li and Liu 2021). Furthermore, the perception of climate change among secondary and primary teachers has been analysed for the case of Brazil (Marchezini and Londe 2020) and in South Africa's Western Cape the knowledge of climate change of secondary teachers has been studied (Anyanwu and Grange 2017).

In Spain, the teaching of climate and weather has attracted academic attention and social interest in recent years in the Spanish education system, as found in the scientific production of prestigious authors who address the teaching of Climatology, such as Martín Vide (2009), Olcina Cantos (2017), Tonda-Monllor and Sebastiá-Alcaraz (2003) and Martínez Fernández and Olcina Cantos (2019). In this respect, particularly noteworthy is the teaching initiative carried out by Morote Seguido (2016), Morote Seguido and Moltó Mantero (2017) and Sánchez Almodóvar et al. (2022) who propose visits to the Climatology Laboratory of the University of Alicante, weather museums and educational exhibitions as an innovative resource and methodology for teaching climatology.

The teaching-learning process of climate change, together with its causes and consequences, is one of the principal challenges of the current Spanish education system, from primary (Morote Seguido 2019a; Morote and Olcina 2021), and secondary education (Olcina Cantos 2017; Morote et al. 2022) to university training (Morote Seguido 2020; Morote Seguido and Hernández Hernández 2020; Sureda-Negre et al. 2014). The non-existence of

a solid line of research on the teaching of climate change from the subject of Geography and Social Sciences in Spain indicates the need for scientific production on the teaching of climate change.

Recent studies reveal the situation of Geography teaching with respect to climate change and natural risks, analysing the school Social Science textbooks in Primary Education (Morote and Olcina 2021; Morote Seguido and Olcina Cantos 2020; Morote Seguido 2019a, 2021; Morote and Olcina 2022) and in those of Obligatory Secondary Education (Serantes-Pazos 2015; Navarro Díaz et al. 2020; Hernández Carretero et al. 2018), which are mostly characterised by a lack of scientific rigour.

From the experimental sciences, there are more proposals and didactic experiences that address the climate crisis from the didactics of Biology and Geology or Physics and Chemistry. There are various proposals with practical laboratory experiences for the different levels of Secondary Education, such as those presented by Sónora et al. (2009), which include: the simple representation of convection currents, testing the regular effect of water temperature, simulating the greenhouse effect and the melting of the poles, and calculating the school's carbon footprint. The latter can cover a whole school year and be developed as a research project for ESO students (Martín Díaz 2009). Specific laboratory experiences can also be addressed, such as the development of a CO<sub>2</sub> sink (Boronat Gil et al. 2018). In addition, the dissemination work carried out by the sciences is essential (Escrivà i Garcia 2021).

The scientific community has difficulty in finding a simple explanation for the evolution of the climate features on a planetary scale and its current status due to the amalgam of factors that intervene (Özdem et al. 2014). To these factors, we should add the stereotypes and reports in the media (Morote et al. 2021a), which can be confusing, as shown by the results of studies that analyse the effect of *fake news* on climate change (Lutzke et al. 2019) and its exposure to the general public depending on the cultural constructs (Hong 2020).

In Spain, two decades ago, Souto González (1998) indicated the lack of studies on the perception of students regarding the teaching of Geography and the lack of training of teachers in the Social Science field. In this respect, in recent years, research has been carried out to determine the social representations and perceptions of the future teachers of Primary Education who are in training (Morote Seguido 2019a, 2019b; Morote Seguido and Hernández Hernández 2020; Morote et al. 2021a) and the knowledge they have on the topic (Morote Seguido and Souto González 2020), as this will have an impact on the perception of primary (Morote and Hernández 2022) and secondary (Sánchez-Almodóvar et al. 2022a) students. Furthermore, the interpretations of postgraduate students have also been analysed (Morote Seguido 2020; Morote et al. 2021b) and those of the whole community of the University of Alicante (Ramos Ribeiro et al. 2014).

### 1.3. Hypothesis and Objectives

The working hypothesis on which this research is based is that, in light of the existing evidence of climate change, this environmental and social problem is one of the principal social challenges of the twenty-first century, but the current paradigm in secondary education reveals that the students do not adequately receive this message through the teaching-learning process and, therefore, are not aware and do not become involved in this global problem. The principal objectives of this study are: (a) to reveal the perception of the students of climate change and natural risks in accordance with the subject in which these contents are taught to them; (b) to analyse whether the students of the third and fourth years of ESO acquire the basic knowledge related to climate change at the end of this cycle, taking into account that these contents are not addressed in later stages.

## 2. Materials and Methods

### 2.1. Design of the Research

This research is based on a descriptive, non-experimental and cross-sectional study as the information analysed has been gathered at a specific moment (academic year 2021–2022) and refers to a case study, in which four public secondary education centres of the province of Alicante in the Region of Valencia are analysed. To do this, the frequency and percentage descriptive of the items studied have been extracted. Similarly, correlational analyses have been conducted in order to predict or learn the degree of association (relationship) between two or more variables through the Pearson correlation coefficient of the items.

### 2.2. Context and Survey Participants

With respect to the context and survey participants, the selection procedure was carried out through a non-probability sampling (availability or convenience sampling). The participants in this study were students of Obligatory Secondary Education (third and fourth years; 13–16 years old or more). The total number of students enrolled in the participating centres for these years was 1248. With respect to the representativeness of the sample and taking into account the total number of students enrolled, in the whole of the area analysed, of the third and fourth years of ESO ( $n = 1,248$ ) a minimum of 295 students was required in order to obtain a representative sample so as to achieve a confidence interval of 99% and a margin of error of 5% (Acuña et al. 2020). Finally, given that the total number of survey participants was 784, a representative number was obtained in order to draw general and not partial conclusions of the phenomenon studied (Table 1).

With respect to the socio-demographic characteristics (gender and age), the figures are similar from a gender point of view: man (47.3%;  $n = 371$ ); woman (45.5%;  $n = 357$ ); prefer not to say (7.1%;  $n = 56$ ).

**Table 1.** Students participating in the research.

Gender	Age				Total
	13 Years	14 Years	15 Years	16 Years or More	
Female	4	136	173	44	357
Male	2	142	175	52	371
Prefer not to say	0	21	22	13	56
<b>Total</b>	6	299	370	109	784

Source: Results of the questionnaire Own elaboration.

In order to ensure the reliability and validity of the instrument of analysis, different tests were conducted. On the one hand, the reliability of the model or instrument constructed has been confirmed through the Cronbach's alpha coefficient. This coefficient consists of the mean of the correlations between the variables that form part of the scale and can be calculated in two ways: based on the variances (Cronbach's alpha) or on the correlations of the items (standardised Cronbach's alpha) (Hair et al. 2011). In this case, the Cronbach's alpha was analysed between the items that made up the instrument (Table 2). A result of 0.789 was obtained, indicating an internal consistency of the instrument, with a value close to 1 (Martínez Arias et al. 2014).

**Table 2.** Cronbach's alpha reliability statistic

Reliability Statistics	
Cronbach's alpha	0.789
No. of items	13

Source: Own elaboration.

In the same way, Pearson's Chi-squared index has been found with results of  $p$ -value  $< 1 = \text{Sig. } 0.001$  (Cohen et al. 2017), indicating the high correlation of the questions asked and illustrative of the validity of the items and structure of the instrument used in the research.

### 2.3. Questionnaire

The instrument designed to carry out the research was based on a questionnaire to obtain the necessary data and fulfil the proposed objectives. The questionnaire was elaborated expressly for this research, following the model of other studies on social perception (Morote et al. 2021b; Morote Seguido 2019b; López-Fernández and Oller Freixa 2019). It was adapted to the non-university school stage and was made up of different items: on the one hand, there was a Likert scale (items 5, 6, 7, 10, 13, 14 and 15); and on the other, questions with diverse response options (items 4, 8, 9, 11 and 12) and socio-demographic questions in order to characterise the participating sample (items 1, 2 and 3) and one open question (item 16) (see Appendix A).

The questionnaire was validated by Secondary Education teachers and researchers from the Experimental and Social Sciences Department of the Social Sciences Teaching division of the University of Valencia; the Social Sciences Teaching Department of Geography of the University of Salamanca; the Specific Teaching Department of the Social Sciences Teaching Division of the University of Burgos; the Mathematical and Social Science Education Department of the University of Murcia; and the Specific Teaching Department of the Social Sciences Teaching Division of the University of Zaragoza.

The validation was carried out through the two-phase "Expert Judgement" method (Galicia Alarcón et al. 2017). In the first phase, the constructed instrument was sent to the experts participating in the validation via email. In this email the objectives of the research were explained, together with the context of the implementation and a period of two weeks was proposed for its evaluation. Subsequently, after receiving the indications of the judges, the items of the instrument were modified. Then, the modified instrument was resent to the same judges. It should be noted that the comments of the judges referred to the wording of the questions and two initial items were merged together.

As a result of this validation, the instrument included 16 items.

### 2.4. Procedure

Before beginning the survey process, authorisation was requested from the Regional Department of Education, Culture and Sport of the Regional Government of Valencia to visit the Secondary Education centres in order to conduct the survey. The request was accepted on 23 December 2021 by the Regional Secretary of Education and Professional Training of the Regional Department of Education, Culture and Sport; under the terms of Decree 173/2020 of 30 October, of the Regional Department, approving the Organic and functional regulations of the Regional Department of Education, Culture and Sport.

The survey process was conducted between December 2021 and June 2022. Contact had been previously made with the head teachers of the educational centres and Social Sciences departments: Geography and History. The questionnaire was administered in collaboration with the teachers of this discipline in one session, with a response time of ten minutes. The students were not previously informed, although the objectives of the research were explained to them once they had been presented with the instrument. Finally, the participants remained anonymous throughout the whole procedure and confidentiality was guaranteed, as indicated in point 5 of the resolution authorising this activity (Resolution 23/12/2021 91K7VMAE: TVL2D461: D85M5MPPM).

### 2.5. Data Analysis

The data analysis procedure was conducted using version 27.0 of the statistics software SPSS. Different statistical-inferential analyses were carried out (non-parametric

tests) of the frequencies and percentages with which the sample was characterised and to determine the perception of the participants of the key concepts of the study. The Pearson's chi-squared test was performed in order to determine the correlation of the validated instrument, which generated a result of  $p$ -value  $< 1 = \text{Sig. } 0.001$ , indicating the high correlation of the questions asked, illustrating the validity of the items and the structure of the instrument. Furthermore, the response to the items was coded so as to conduct a cross tabulation analysis and bivariate correlations in order to characterise and establish differences and correlations with respect to the concept of climate change and its relationship with the greenhouse effect, in accordance with the subject in which these contents were taught to the students.

### 3. Results

First, a frequency ( $f$ ) and percentages (%) analysis was carried out of the responses to item 4: "Subject in which you have been taught about climate change", in order to determine the subject perceived by the participating sample of third- and fourth-year ESO students (item 2: "Gender"; item 3: "Which year are you in"), that teaches the contents relating to the concept of study (climate change). The global data (a total of 784 responses) reveal that the principal subject in which this topic is taught is Geography and History (Table 3).

Therefore, it is observed that the students perceive the subject of Geography and History as the one in which the concept of climate change is addressed ( $f = 354$ ), with a representation of 45.3% of the responses of the participating sample. In second place, the students consider that the subject of Biology and Geology addresses these contents ( $f = 142$ ) with a representation of this answer option of 18.1%. Finally, the participants gave a lower response percentage to the subject of Physics and Chemistry ( $f = 32$ ), with a significance with respect to the total percentage of responses of 4%.

**Table 3.** Frequency and percentages of the perception of the students by year and gender of the subject in which climate change is addressed.

Subject in Which You Have Been Taught about Climate Change	Group												TOTAL	
	Third Year of ESO						Fourth Year of ESO							
	Gender						Gender							
	<i>w</i>		<i>m</i>		<i>pns</i>		<i>w</i>		<i>m</i>		<i>pns</i>			
<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	
Geography and History	111	14.1	111	14.1	12	1.6	62	8	55	7	3	0.4	354	45.3
Physics or Chemistry	15	1.9	8	1	6	0.7	0	0	2	0.3	1	0.1	32	4
Biology or Geology	30	3.8	24	3	5	0.6	34	4.3	47	6	2	0.25	142	18.1
I have not learnt about climate change	63	8	80	12.2	25	3.2	42	5.3	44	5.5	2	0.25	256	32.6
<b>TOTAL</b>	219	28	223	28.4	48	6.1	138	17.6	148	18.8	8	1	784	100

Notes: Legend:  $f$  = frequency;  $w$  = woman;  $m$  = man;  $pns$  = prefer not to say. Source: Results of the questionnaire Own elaboration.

It is worth pointing out the option "I have not learnt about climate change" with a high representation among the responses given by the sample of 32.6% of the total ( $f =$



256). By gender, the above-mentioned responses are the same, with the subject of Geography and History being the most indicated equally by men and women than those who prefer not to define themselves as either a man or woman. Similarly, the response “I have not learnt about climate change” is in second place from a gender point of view.

If we observe the responses by the academic year of the students, the same trend is observed. In first place, Geography and History is perceived as the subject in which the contents relating to climate change are addressed (third-year ESO  $f = 234$ ; fourth-year ESO  $f = 120$ ). In addition, the response “I have not learnt about climate change” is the second most popular option selected by the students of third-year ESO ( $f = 168$ ) and fourth-year ESO ( $f = 88$ ) students.

In order to analyse whether the students perceive climate change as a threat and whether they relate it to extreme weather events, item 7 “Is climate change a threat to human beings” has been interrelated with item 10 “Do you think that more extreme weather events are occurring now? (extreme weather events can be hurricanes, torrential rains, heatwaves, etc.)” (Table 4). In this respect, it should be noted there is considerable quorum among the students ( $f = 586$ ) who believe that climate change is a threat and that extreme phenomena are increasing, representing 74.8%. However, some students ( $f = 86$ ), while believing that climate change is a threat, are not sure that more extreme weather phenomenon are occurring now (10.9%): A small number of the sample ( $f = 20$ ), representing 2.5%, express uncertainty for both of these questions. With respect to the total data, it should be pointed out that 5.7% believe that climate change is not a threat ( $f = 45$ ).

**Table 4.** Frequency and percentages of the perception of students in relation to climate change and the development of associated extreme weather phenomena

Item 7. Is Climate Change a Threat for Human Beings?	Item 10. Do You Think That Now There Are More Extreme Weather Events? (Extreme Weather Events Can Be Hurricanes, Torrential Rains, Heatwaves, etc.).						Total	
	Yes		No		Don't Know/No Answer		f	%
	f	%	f	%	f	%		
Yes	586	74.8	16	2	86	10.9	688	87.8
No	26	3.3	8	1	11	1.5	45	5.7
Don't know/no answer	28	3.5	3	0.4	20	2.5	51	6.5
<b>Total</b>	640	81.6	27	3.4	117	14.9	784	100

Legend:  $f$  = frequency. Source: Results of the survey. Own elaboration.

In order to determine the linear dependency between the responses given by the sample for item 7 and item 10, the Pearson’s correlation was found (Table 5). The results show that there is a strong correlation between the two questions referring to climate change. Furthermore, the responses to both items show a statistically significant linear relationship ( $r = 0.683, p < 0.001$ ). The direction of the relationship is positive, which means that these variables tend to increase together in relation to climate change. As we can observe in Table 5, the magnitude or strength of the association between the perception of risk for human beings of climate change and the ever-greater proliferation of extreme weather events as a consequence of this climate change (between 0.5 and 1) is strong.

**Table 5.** Pearson’s correlations for the responses related to climate change (items 7 and 10).

		<b>Item 7. Is Climate Change a Threat for Human Beings?</b>	<b>Item 10. Do You Think That Now There Are More Extreme Weather Events? (Extreme Weather Events Can Be Hurricanes, Torrential Rains, Heatwaves, etc.).</b>
<b>Item 7. Is climate change a threat for human beings?</b>	<b>Pearson’s correlation</b>	1	0.683 **
	<b>Sig. (bilateral)</b>		0.000
	<b>N</b>	784	784
<b>Item 10. Do you think that now there are more extreme weather events? (extreme weather events can be hurricanes, torrential rains, heatwaves, etc.).</b>	<b>Pearson’s correlation</b>	0.683 **	1
	<b>Sig. (bilateral)</b>	0.000	
	<b>N</b>	784	784

Note: \*\* means the correlation is significant at the 0.01 level (bilateral). Source: Results of the questionnaire Own elaboration.

With respect to item 8 of the research instrument (Appendix A), four responses are proposed (natural factors; factors derived from human action; there is no climate change; do not know, no answer) in relation to the principal causes of the current process of climate change. The majority of the participating sample responded to this question with the option “factors derived from human action” with 91.3% of the answers ( $f = 716$ ). The second most chosen answer was “natural factors” with 5.3% of answers ( $f = 42$ ) and the third was the option “dk/na” with 1.7% of answers ( $f = 14$ ). It is striking that the response option “there is no climate change”, which, while being the least chosen response had a percentage very close to “dk/na” with 1.5% of the responses obtained ( $f = 12$ ).

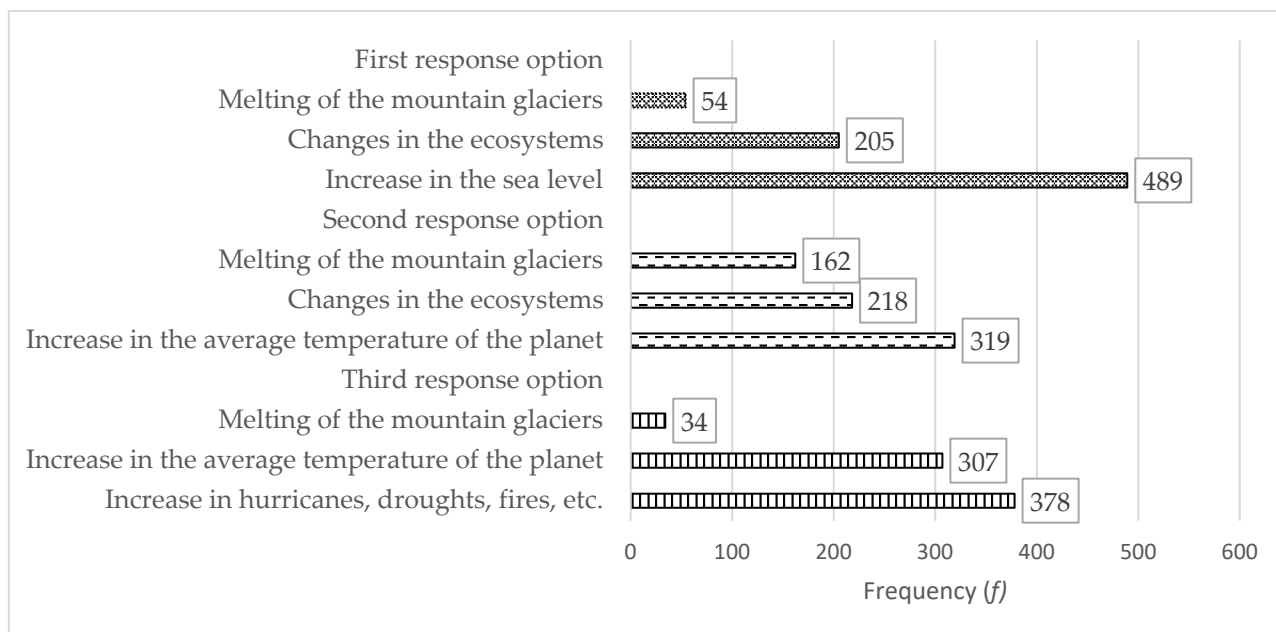
When we observe the responses by groups (third year of ESO and fourth year of ESO), we can see that, in both years the majority option selected is “factors derived from human action” representing 56% of responses from third-year ESO students ( $f = 439$ ) and 35.5% of responses of fourth-year ESO students ( $f = 277$ ) (Table 6).

**Table 6.** Response options regarding factors that influence climate change by school year analysed.

<b>Item 8. If the Following Factors That Contribute to Climate Change, Which Do You Consider to Be the Principal Cause of the Current Climate Change Process?</b>	<b>Natural Factors</b>		<b>Factors Derived from the Action of Human Beings</b>		<b>Climate Change Does Not Exist</b>		<b>Dk/Na</b>		<b>Total</b>	
	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
	<b>Third-year ESO</b>	32	4	439	56	7	0.8	12	1.5	490
<b>Fourth-year ESO</b>	10	1.3	277	35.3	5	0.7	2	0.2	294	37.5
<b>Total</b>	42	5.3	716	91.3	12	1.5	14	1.7	784	100

Legend: Dk/na – don’t know/no answer Source: Results of the questionnaire Own elaboration.

Item 9 refers to the consequences derived from climate change. With the objective of determining the consequences that the students perceive as being most important, the item is presented as a multiple response question where the participants must select the three most important options in accordance with their criteria. Figure 3 shows the absolute frequencies of the responses selected as first, second and third options. In the first response option, the most frequent answer was “Increase in sea level” ( $f = 489$ ), representing 62.4%, followed by “Changes in the ecosystems” ( $f = 205$ ) representing 26.1%, and finally, the option with the lowest frequency in this group was “Melting of the mountain glaciers” ( $f = 54$ ) with a representation of 6.9%. As a second response option, the most selected by the participants was “Increase in the average temperature of the planet” ( $f = 319$ ), representing 40.7%, in this group the option “Change in the systems” was repeated ( $f = 162$ ), representing 27.8%, while “Melting of the mountain glaciers” ( $f = 162$ ) was third with 20.7% of the answers. In the third response option, the most selected by the students was “Increase in hurricanes, droughts, fires, etc.” ( $f = 378$ ), with 48.2%. This result is related to the 81.6% ( $f = 640$ ) (Table 4) who consider that now extreme weather events occur more frequently. With very little difference, the option “Increase in the average temperature of the planet” ( $f = 307$ ) represented 39.2% of responses. The least frequently selected option was “Melting of the mountain glaciers” ( $f = 34$ ) with just 4.3%.



**Figure 3.** Response options regarding the consequences of climate change. Source: Results of the questionnaire Own elaboration.

#### 4. Discussion

The teaching and dissemination of climate change and natural risks is essential for developing social awareness, which help to enhance our understanding of the causes and consequences of these processes so as to sensitise the population about prevention and adaptation measures.

The results obtained in this research reveal the importance that geographic science has in the teaching of climate change and natural risks, given that 45.3% of the students surveyed have worked on this topic in the subject of Geography and History in their secondary education. In spite of this, 32.6% of the participants claimed that they had not seen contents related to climate change. Similar results were obtained in the study conducted by Özdem et al. (2014) with primary education students in Turkey, where 24% of the sample had not heard of climate change and 23% were not sure, as opposed to 52% who responded positively. In the case of young Canadian people, the level of confidence was not

high with respect to the question about how sure they were of the education they had received at school about climate change (Pickering et al. 2020). A study on the perception of Brazilian primary and secondary teachers revealed that 60.3% of the total participants had not received training in climate change when they were undergraduate students (Marchezini and Londe 2020).

With respect to the question about whether climate change represents a threat to human beings, in this study the majority of the sample (87.8%) responded affirmatively. This result coincides with that obtained in the case of the Brazilian teachers, with 83.5% considering that climate change is affecting the municipality (Marchezini and Londe 2020). With respect to the statement that climate change is a threat to life, the results of this study coincide with those obtained by Gómez Trigueros (2020) where the university students participating in the classroom intervention considered that climate change is produced and expressed in our daily lives. However, only 41% of the primary students (Turkey) perceive climate change as a threat, while 40% are not sure and 19% consider that they are not affected or will not be affected (Özdem et al. 2014).

The findings obtained in this research show that 81.6% of secondary students perceive an increase in extreme weather events as a result of climate change. These are similar to those obtained in other studies analysing perception, in this case students of the Primary Education Degree of the University of Valencia, who were asked whether climate change is influencing the increase in flood risk, to which 63.52% of the participants responded affirmatively (Morote Seguido 2019b, p. 78). In the same area of study but with a different context, 70% perceive that rainfall episodes are more intense (Morote Seguido and Hernández Hernández 2020).

According to the IPCC (2021, p. 425), the hypothesis of human influence as the cause of the current climate change process has been reinforced with the evaluations conducted from the second report of the IPCC in 1995 to the fifth in 2014 which reveal the clear human influence on the climate system, due to the increase in greenhouse gas emissions into the atmosphere. This idea has gained force and has been demonstrated in the last report. Therefore, in this research, it is interesting to determine the perception of the students regarding this fact, with the majority (91.3%) considering that human factors influence climate change. A recent study conducted for the Region of Valencia (Spain) analyses the perception of primary, secondary and baccalaureate students, revealing that the students consider that the principal cause of this phenomenon is attributed to pollution (70.1%) (Morote and Hernández 2022). Similarly, Jamelske et al. (2013) compare the opinion of Chinese and American university students regarding whether the principal causes of climate change are human or natural. The Chinese students principally believe (86.4%) that climate change has anthropogenic causes, while barely 59% of the American students also believe this to be the case. In the same way, 82% of Brazilian teachers consider that the principal cause is due to the increase in carbon emissions (Marchezini and Londe 2020). In contrast, only 38 % of university students in Taiwan identify anthropogenic activity as a cause of global warming (Li and Liu 2021).

When young people hear about climate change their first thought is principally related to the consequences, as shown by González-Gaudio and Maldonado-González (2014) in their study on the social representations of university students in Mexico. Similarly, Bello Benavides et al. (2021) examine the social representations of baccalaureate students in Mexico, where the increase in temperature, the greater presence of extreme weather events and the increase in sea level are the most recognised consequences of climate change. With respect to this study of the consequences, the results of the survey carried out among secondary students show that the responses most frequently selected were "Increase in sea level" (62.4%), "Increase in the average temperature" (40.7%) and "Increase in hurricanes, droughts, fires, etc." (48.2%). Similar results were obtained by Morote and Hernández (2022), where the participants indicated that the principal effect of climate change is the "Increase and changes in temperature" (61.7%), in second and third place they indicated "Melting" (8.7%) and "Increase in natural threats" (5.6%).

Taking as a base the new Organic Law 3/2020, of 29 December on Education (LOMLOE), which bestows greater importance to the teaching of the contents related to the environment, natural disasters and climate change, this research reveals the need to address climate change and avoid catastrophism and present the evidence realistically, based on reports and scientific data. It shares the proposal made by Martínez Fernández and Olcina Cantos (2019), with the introduction of new contents on the risks associated with climate and climate change for primary and secondary education and the proposal made for the level of third year of ESO is particularly interesting for this study. In the same way, the results obtained from the in-depth reviews of the existing contents on climate change in primary education textbooks (Morote and Olcina 2021; Morote Seguido and Olcina Cantos 2020; Morote Seguido 2019a, 2021; Morote and Olcina 2022) and, principally secondary education textbooks (Serantes-Pazos 2015; Navarro Díaz et al. 2020; Hernández Carretero et al. 2018), highlight the need to address this topic with more scientific rigour. Meanwhile, in a study on the subject of climate change at university level, Gómez Trigueros (2020), conducts an intervention in a classroom of future primary education teachers, giving a prominent role to GIS as a didactic innovation in teaching climate change, stressing again the importance of addressing this problem on a local scale (Gómez-Trigueros et al. 2019) and taking into account in the teaching-learning process the interrelationship between human beings and the natural or artificial environment (Martínez Castillo 2010). With a more informative nature, the proposal made by Nelles and Serrer (2020) is a clear example of how to address the communication and teaching of climate change simply and directly, but with a high level of scientific rigour through illustrations that clearly transmit the causes and consequences of the phenomenon, its effects and even response actions to the climate emergency, which are useful as a teaching resource in the classroom.

## 5. Conclusions

This study analyses the perceptions of the students of third and fourth year of ESO with respect to the topic of climate change and natural risks. It explores the subjects in which the students consider that these contents are addressed more precisely. The results show that Geography is the predominant subject, which ratifies its suitability to address issues related to climate change.

The knowledge acquired by the students in their obligatory education on climate change, the associated extreme weather events and consequences has been assessed. The study shows the need to study current climate change in greater depth in the classroom, the influence of human beings on the development of this climate change, the territorial and socio-economic effects of global warming and the future evolution of this process. Although in recent years there has been an increasing mobilisation of students in aspects related to the current climate crisis, it is necessary improve the contents taught in the classroom on climate change, which should not focus on extreme or catastrophic messages but should be based on rigorous scientific data and official reports on the topic.

All of this has the objective of generating a society better adapted to the future climate change scenarios. The development of materials on climate change and the associated extreme weather events contemplated in the new Education Law (LOMLOE; Law 3/2020 of 29 December) can constitute an ideal framework for learning about this topic at pre-university levels. Furthermore, it is vitally important to establish a new horizon in teaching, within the framework of the 2030 Agenda and the development of the SDGs (Naciones Unidas Asamblea General 2015), and the Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations General Assembly 2015), as a tool to raise awareness, change attitudes, focus on the importance of reducing existing risk and on the strengthening of a sustainable and resilient society.

However, we should be aware that the implementation of these proposals in the classroom could be hindered by: (1) a lack of training received by Geography and History teachers (it should be noted that in Spain many of the teachers of this subject have a History background); (2) the scientific rigour of the explanations in the textbooks; a matter

widely discussed by Morote Seguido and Olcina Cantos (2020) or (3) the influence of the media and social networks. Therefore, when the topic of climate change is brought to the classroom it should be based on a series of premises which avoid the recurrence to catastrophism and the formulation of sensationalist theories. To do this, it is necessary to educate not only the students, as a basic part of the general population, avoiding the propagation of *fake news* and misinformation by the different media. The emergence of the youth movement “*Friday For Future*” represents a step forward for this population group to become involved and participate in the defence of the planet and the fight against climate change, as they will inherit the initiatives that are currently being implemented.

Therefore, the role played by the academic institutions (universities, research centres) is important for divulging climate science, with the development, using clear and accessible language, of materials, talks or guided tours that bring students of basic levels of education into contact with the climate reality of our planet and can already be observed on scales close to them (regional and local). The new information tools (ICTs, viewers, apps) and social networks can play an important complementary role to the methods traditionally used in the classroom, due to their educational capacity and degree of social penetration in the youngest layers of society. These actions should always pursue the improvement of environmental culture and the respect for the environment.

Among the future development in this line of research is the analysis of other concepts related to climate change, such as the greenhouse effect, the analysis of the perception of flood risk and the decision-making processes involved in them both. Another line is to determine the opinion of students regarding the governance of climate change and their personal action proposals.

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## Appendix A

Item	Type of Response/Variable
Item 1. Gender	Closed question: Female/Male/Prefer not to say
Item 2. Age	Closed question: 13/14/15/16 or more
Item 3. Year	Closed question: 3rd year ESO/4th year ESO
Item 4. Subject in which you have been taught about climate change.	Closed question: Geography and History/Physics or Chemistry/Biology or Geology/I have not learnt about climate change
Item 5. Is the greenhouse effect a natural process?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 6. Is the greenhouse effect positive for life on Earth?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 7. Is climate change a threat for human beings?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer

Item 8. If the following factors that contribute to climate change, which do you consider to be the principal cause of the current climate change process?	Closed question: Natural factors/factors derived from the action of human beings/Climate change does not exist/Dk/Na
Item 9. Indicate the consequences of climate change (Mark the most important options in accordance with your criteria)	Multiple question: Increase in the sea level/Changes in the ecosystems/Increase in volcanic activity/eruptions/Melting of the mountain glaciers/Increase in the average temperature of the planet/Increase in hurricanes, droughts, fires, etc./Climate change does not have any consequences/Increase in earthquakes
Item 10. Do you think that now there are more extreme weather events? (extreme weather events can be hurricanes, torrential rains, heatwaves, etc.).	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 11. Which natural phenomenon do you consider most important in your town and the province of Alicante?	Closed question: Floods/Droughts/Earthquakes/Fires
Item 12. With respect to floods in towns, what do you think is the principal cause?	Closed question: The urban growth of the towns has occupied floodable areas/The rivers overflow/The amount of rainfall is higher/There are no floods in urban environments
Item 13. Would you know how to act in a situation of flood alert?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 14. Do you consider that the government authorities are implementing solutions to the problem of climate change?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 15. Do you think that you could do something to fight against climate change?	Likert scale: (1) Yes/(2) No/(3)Don't know/no answer
Item 16. If yes, indicate what you would do to fight against climate change. If no, why cannot you fight against climate change?	Open question

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