

Exploring the Beliefs, Concerns and Understandings About Climate Change of Greek University Students from the Social Sciences and Humanities



Maria Daskolia

Abstract Higher education institutions have a critical role to play in preparing young generations to become better aware and more responsible citizens to cope with climate change. Universities must align their curricula to help students develop the necessary understandings and skills. Yet, to be able to organize this, it is necessary to know, among other things, what students believe, feel and understand about climate change and how informed they are about it. However, most of the research conducted so far has focused mainly on primary and secondary school students' beliefs, attitudes and understandings, while the few studies addressing university students are limited to science students or students enrolled in science courses. The study reported here was conducted within a Greek University. It surveyed 250 undergraduate students from the Social Sciences and Humanities. Students were asked to fill out a questionnaire which aimed to assess their beliefs and concerns about climate change, their self-reported degree of knowledge and their understandings about how the climate system works, factors that contribute to global warming and actions to reduce it. Data analysis showed that most students believe that climate change is real and largely human-induced, and express their concern about it. Yet, there are gaps, uncertainty and misconceptions in the students' understanding of climate science and about the impact of different factors and measures. Most students agree that both schools and Universities must teach youths about the causes, consequences and solutions to climate change, and express their need to learn more about the issue. The study's findings lay out the path for possible integration of climate change education in the Social Sciences and Humanities academic programs.

M. Daskolia (✉)

Environmental Education Lab, Department of Educational Studies, School of Philosophy, National and Kapodistrian University of Athens, University Campus, 15722 Zografou, Greece
e-mail: mdaskol@eds.uoa.gr

1 Introduction

Climate change is one of the direst, most pressing and multifaceted challenges of our times. All countries and societies across the globe are being affected by the manifold harmful impacts of global warming on human-nature systems (Hansen and Stone 2016). The Mediterranean Basin and all countries pertaining to it are among the regions that are prone to be affected most by the impacts of actual and future climate changes (Ozturk et al. 2015; Cramer et al. 2018). To address the risks and consequences of climate change and promote sustainable development, informed climate action at a local, national and international scale is needed. Climate Change Education (CCE) is at the core of this action aiming to enable future generations to make responsible decisions and adopt sustainable lifestyles in order to confront the challenges raised by climate change (UNESCO 2017). To this end, ‘*changing mindsets, not the climate*’ is the communication message eloquently put forward by UNESCO to briefly delineate the role education is envisaged to play in empowering people, youths in particular, to get involved in meaningful action against climate change.

Fostering new competences and strengthening the voices of the so-called “*climate change generation*” (Feldman et al. 2010) has never been more important. The Paris Agreement in Article 12 stresses the need for fostering “*climate change education, training, public awareness, public participation and public access to information*” across all sectors (UNFCCC 2015). It also calls for the development of new academic programs to ensure that young generations will develop a comprehensive understanding of the interrelated challenges put forth by climate change and the actions necessary to be activated (UNESCO 2017). While education at all levels, from preschool to higher education, is acknowledged as a key dimension of international climate action (UNFCCC 2015), Universities have a critical role to play in supporting students to acquire the necessary knowledge, attitudes and skills (Leal Filho 2010; Wachholz et al. 2014; Leal Filho et al. 2018; Leal Filho and Hemstock 2019). Apart from leading multi-disciplinary research, contributing to the debate or setting the climate change policy agenda, Universities are teaching institutions that address large numbers of (young) people. They are, therefore, in a key position to raise awareness and educate their students on a lifelong understanding of climate change issues.

University students are a key target audience for CCE because of their dual identity of being young adults and future professionals at the same time. As ‘emergent adults’, Ojala (2020) argues that they belong to a ‘transitional’ age group, which is more likely to develop new knowledge and to re-examine previously acquired norms and habits. Such a learning potential is coupled by the fact that they are trained to become professionals who will need to base their future work-related decisions on an informed climate change perspective. For all these reasons, higher education curricula need to provide university students with a range of CCE opportunities (Molthan-Hill et al. 2019), taking into consideration both the particularities of the disciplinary field and the professional qualifications set by different academic programs and the

students' current levels of awareness, concerns and understandings about the climate change issue. Some important first steps have been taken towards this direction but there are still many more to work through (Leal Filho et al. 2018; Molthan-Hill et al. 2019).

Understanding how young people approach climate change can inform the design of CCE courses and programs. Research so far has been mainly focused on investigating the general public's perception of climate change (see among others, Weber and Stern 2011; Smith and Joffe 2013; Whitmarsh and Capstick 2018; Ballew et al. 2019) and on informing communication and policy actions. A considerable bulk of research has also been directed towards documenting and exploring primary and secondary school students' misconceptions about climate change (i.e., Boyes et al. 1993; Skamp et al. 2009; Shepardson et al. 2012; Stevenson et al. 2016; Hermans and Korhonen 2017; Jackson and Pang 2017). Comparatively fewer studies have been focused on investigating university students' beliefs, concerns and understandings of climate change.

Earlier studies in the field are mostly surveys of US American samples of graduate students with a science background or enrolled in sciences courses (Wachholz et al. 2014). They intended to measure the students' depth and accuracy of scientific knowledge about the greenhouse effect, global warming or climate change (these terms were used interchangeably), sometimes in conjunction with other environmental issues, mainly the ozone hole. Most studies report a wide range of misunderstandings about climate change among geology students (Wilson and Henson 1993) or students enrolled in an environmental science course (Morgan and Moran 1995). Misconceptions concerning the impact of the ozone hole on climate change were also reported among US students with a chemistry major (Kerr and Walz 2007) or students enrolled in a meteorology course (Cordero et al. 2008). In one study with college students majoring in elementary education (Khalid 2003), measurement of knowledge around the greenhouse effect, atmospheric ozone, and acid rain also brought up similar misconceptions and misunderstandings. All these studies reveal a rather high degree of confusion and uncertainty, mainly among science students, over several dimensions of the climate change issue, despite the fact that students identify climate change as an important environmental problem and express a high level of concern (Cordero et al. 2008).

A more recent US study, although quite influential on an international level, is the one by Wachholz et al. (2014). They surveyed 375 US college students representing a cross-section of disciplines, ranging from the humanities, social sciences, sciences, business, and other applied professions. The study attempted to go beyond previous research in the field by mostly focusing on measuring higher education students' scientific understanding of climate change and their views on and willingness to combat it. With the use of a questionnaire, the study explored the students' knowledge, attitudes, and understandings about the causes and possible consequences of climate change; their intentions and commitment to reduce their personal greenhouse gas emissions; and their degree of satisfaction with the CCE provision at university level and their suggestions for improving it. The study concluded that the majority of students believed climate change is occurring and that it is basically a

human-induced environmental issue. Approximately two-thirds of the respondents reported being concerned about climate change, even though their worries were not reflected in some kind of action to mitigate it. Although most of them perceived their knowledge about climate change to be sufficient, they did not answer some basic questions about it correctly. Almost half of the students believed that there was a high degree of disagreement among scientists about whether climate change is real, and many of them viewed it as a slow and distant problem, unrelated to their current well-being. Finally, a high percentage of students reported being dissatisfied with the CCE opportunities provided by their University.

In a Mediterranean context, there are a few national and cross-national examples of research focusing on university students' beliefs, concerns and understandings of climate change. Among the first studies and the only one conducted so far with a Greek university student population is that by Manolas et al. (2010). The sample consisted of 245 forestry students enrolled in one University in Northern Greece. A questionnaire was designed and administered to the students during the examination period, asking them, among other things, about their views on the seriousness of the climate change issue, the factors contributing to the greenhouse effect, the causes of global temperature increase, and the efforts to solve the problem. The study's findings indicated that the students recognized the climate change problem as important. Among the factors contributing the most to the greenhouse effect, sources that produce greenhouse gases and human actions and policies that intensify the problem were identified. Global temperature increase was perceived by the students to be caused mainly by industrial activity, CFCs, deforestation, energy plants and transportation. Among the factors rated as least important were central heating installations, the increase in global population, household waste dumps, and agricultural and cattle-raising activities. Respondents expressed the view that global temperature rise caused by the greenhouse effect is under the individual's control. They expected that adverse consequences will be particularly obvious in the future and that their generation will be negatively affected by them. Despite their pessimistic forecasts, one in three students deemed that all present efforts are useful. Even though they declared willingness to support all measures for reducing carbon emissions, the majority of them was rather reluctant or negative to bear the brunt of such measures.

Most of the studies conducted either with a Spanish or a Portuguese university student population are cross-national, involving at least one more, Latin American or other European, university student sample. In one of the first studies in such context, Bråten et al. (2009) explored and compared the personal epistemologies with respect to climate change across 225 Norwegian and 217 Spanish undergraduates attending studies in Psychology and Education with the use of a 49-item questionnaire. They also examined the relationships between epistemic beliefs about climate change and the students' gender, knowledge and interest in the topic. The study indicated the cultural embeddedness of epistemic beliefs about climate change, and pointed to some factors restricting or enhancing such beliefs. More particularly, simplicity beliefs were found to be more evident among Norwegian students, while certainty beliefs among Spanish students. However, the study concluded that further research was necessary to explore the cultural variables at the root of observed differences

and to discern whether such differences are related to a different emphasis of public discourse in Northern Europe in terms of the climate change's negative consequences, compared to a focus on the certainty aspect of knowledge about climate change in Southern Europe.

In another study that was carried out with a cross-national sample of 484 young university students, students from Spain and Italy (together with students from Brazil, China and the United States) were asked to examine how they perceive media communication in relation to the scientific consensus over climate change (Díaz Estévez et al. 2014). Data were collected through a survey questionnaire that was designed and distributed to the students during class hours. The study suggested that despite the fact that climate change seems to be part of a global culture and related to the values defining this generation's interests, respondents showed they had a rather superficial knowledge of climate change causes. They also had a deficient knowledge regarding scientific consensus over climate change. The majority recognized there is human intervention in climate change, while more than half considered that climate change is also caused by natural factors. When asked about the most reliable media to expand their knowledge about climate change, they named films (both fiction and documentaries), although social media is where they usually search to get information about the topic, followed by online press and television. Finally, respondents expressed the view that an interdisciplinary approach is essential to tackle problems related to climate change.

A more recent study conducted on a Spanish students sample is the one by Arto-Blanco et al. (2017). 219 Mexican and 284 Spanish undergraduate students from various faculties of two national Universities participated in the study. The researchers used both qualitative (drawings and text) and quantitative (questionnaire) measures and analysis to explore the students' social representations of human responsibility regarding climate change. The study's results indicated that although most participants identified human agency as the cause of climate change and recognized that everyday human activities aggravate the problem, there were gaps in the students' understandings about it. Greenhouse emissions were primarily associated with industry and the use of automobiles, while domestic consumption (in energy or food) was not among the factors identified. General pollution or specific forms of it, along with other environmental degradation processes, such as deforestation, were acknowledged to contribute to the problem. Spanish students referred to the use of vehicles followed by recycling and waste management as the individual activities mostly contributing to climate change, even though they could not specify how. They also emphasized economic growth and industrialization as the main culprits of climate change compared to Mexicans who identified exclusively individual activities. Spanish students tended to acknowledge different levels of citizen responsibility compared to Mexicans. The study concluded that 'cultural variables' seem to have a more decisive role in the students' conceptualization of climate change, over-exceeding the one 'academic field' or 'year of study' have on climate literacy patterns.

Another recent study conducted exclusively on a Portuguese university sample is the one by Santos et al. (2016). The study addressed the views and attitudes about

climate change among 124 postgraduate students attending three master programs in environmental sciences in 3 Universities respectively. A self-completion questionnaire consisting of 30 closed-ended and two open questions adapted from Wachholz et al. (2014) and Manolas et al. (2010) was administered to the students. The study's findings indicated that nearly all respondents believed that climate change is real and largely induced by humans. They also expressed their concern about climate change and the view that the scientific community is in agreement. However, less than half of them believed that their Master academic training had focused enough on the topic, and expressed the need for more information. The majority reported they had a moderate technical knowledge about the issue. The study also pointed to some misconceptions the students held about the causes and consequences of climate change, such as about the effect of the ozone hole on it.

The same 124 Portuguese students were also part of the cross-national sample in the study reported by Morgado et al. (2017). 40 Mexican and 40 Mozambican postgraduates completed the same questionnaire in a study aiming to investigate the students' perceptions, motivations, attitudes and knowledge about climate change in three cultural contexts. The study's findings indicated that most respondents across all three nationalities believed that climate change is happening, although Mexican students were significantly less certain compared to the Portuguese and the Mozambicans. Mozambican students were significantly much more interested in climate change. They all believed that biotic communities were being impacted by climate change in all parts of the world and that their country was already experiencing these impacts. All were, nevertheless, quite optimistic that humanity can mitigate climate change effects. They also believed that their training was quite focused on climate change issues. However, the students were not so much knowledgeable about how their actions could influence climate change and expressed the need for more information about it.

In our literature review three more studies were identified focusing on university students' beliefs and understandings about climate change originating from other Mediterranean countries, and more specifically, Turkey, Croatia and Egypt. In their research, Ateş et al. (2017) investigated Turkish undergraduate students' beliefs about the occurrence, causes and consequences of global climate change, and how and to what extent future time perspective along with perceived knowledge and environmental attitudes could be predictive factors. A large sample of 1,580 students distributed across 5 Faculties in one state Turkish university participated in the study and were asked to complete an adapted 14 closed-ended questionnaire. The majority of the students agreed that global warming is occurring, it is caused mainly by human activities and would bring about negative consequences, with female students holding stronger beliefs over these issues. However, the authors underline the fact that smaller percentages of students were uncertain or did not believe that any of these three dimensions was true. The study concluded that the majority of the students felt they had moderate to limited knowledge about the causes and consequences of global climate change.

The study by Nefat and Benazić (2019) produced similar results to the ones in previous studies. Their survey was conducted on a sample of 253 graduate and undergraduate students in the Faculty of Economics and Tourism of one Croatian University. The data were collected with the use of a questionnaire that was adapted from more instruments developed in previous studies. Descriptive data analysis demonstrated that the large majority of Croatian students agree that climate change is actually occurring, it is human-induced and there is consensus among scientists about it. The researchers commented that the relatively higher percentages derived from their study compared to previous research are possibly due to the growing awareness about climate change worldwide. However, although more than half of the students consider climate change a serious threat to humankind, themselves and their families, they feel moderately informed and they would be interested in learning more about it. They stated that climate change is not part of their academic curricula, even though most of them had dealt with the topic in school.

Finally, the only study carried out in a non-European Mediterranean context is the one reported by Ibrahim et al. (2018). A large number (1,300) of students from four Faculties of an Egyptian University took part in a survey, which aimed to investigate their knowledge and attitudes about global warming. The data were collected with the use of a questionnaire which was based on instruments used in previous studies to assess school students' knowledge and attitudes about global warming. The study results indicated that the majority of Egyptian held positive attitudes toward the issue, however their level of awareness differed depending on their discipline: a higher percentage of students with a background from the Sciences and Agriculture were better aware compared to students pursuing studies in Commerce or Law. In terms of their knowledge about what causes global warming, most students identified car emissions, industrial pollution, and the burning of domestic and agricultural waste as the main factors contributing to it.

The study reported here is part of a greater research project initiated by the Environmental Education Lab research center of the National and Kapodistrian University of Athens (NKUA), the oldest and largest institution of Higher Education in Greece and among the largest and most well-known universities in Europe and the Mediterranean region. Comprising 32 Faculties and their respective Departments, and functioning within 8 Schools, the NKUA offers a wide range of undergraduate courses and almost 100 postgraduate programs. Based on a survey conducted during 2015–2016 to identify the degree to which Greek Universities had incorporated climate change issues into their curricula (Skanavis et al. 2017), the NKUA was found to have a rather limited outreach. Although these data may have been altered considerably in the meantime, it is worth investigating both the baseline and the potential for promoting CCE across the NKUA programs of study. The research project that is being conducted by the Environmental Education Lab aims to explore the climate change literacy profiles and types of learning engagement of the NKUA students from a wide range of disciplinary fields and programs of academic studies and to assess their levels of awareness, concern, understanding and learning disposition

in relation to climate change. It also aims to determine differences in the knowledge, understanding and learning of climate change among students from different Faculties and based on various socio-demographic and behavioral factors.

2 Method

The survey was conducted between November 2019 and January 2020 with a sample of first-year graduate students from the Faculty of Social Sciences and Humanities (namely the School of Philosophy), and more particularly students enrolled in the Departments of Psychology and Philosophy. Convenience sampling was used and 250 students were contacted in the context of their participation in introductory courses, after personal communication with the Lecturer(s) responsible for the course(s) and permission granted. The students were approached in class, before the start of the lecture. The topic and purpose of the study were explained to them and they were asked to provide their free and informed consent prior to completing the questionnaire. Students were assured that their responses would remain anonymous and that their overall performance in the questionnaire would not affect their academic grades.

Data collection was based on a questionnaire composed of 26 closed-ended and 2 open questions. For close-ended questions a 4-point Likert scale or a single-choice answer format from a list was used. Seven more questions were included to collect basic socio-demographic information (gender, age, university department, year/semester of academic studies, place of origin, father's and mother's education level). Twenty questions were closely modeled on the survey instrument used by Leiserowitz et al. (2011), with a nationally representative sample of 517 American teens (aged 13–17) and 1,513 American adults, to measure and compare their knowledge, concern, and beliefs about climate change. The questionnaire was developed and used in several national and international opinion poll surveys within the context of the Yale Project on Climate Change Communication (<https://climatecommunication.yale.edu/>). An appendix with the correct answers to the questions, all supported by well-established scientific evidence and references to peer-reviewed scientific sources, is also provided in the same report. All questions selected from the Yale Project's survey instrument were translated into Greek by the author and accuracy was checked by a second English-speaking researcher.

The questionnaire was pre-tested with 23 graduate students from the Department of Educational Studies (NKUA) to identify any comprehension and language issues and to improve its face and content validity. Questionnaire completion took on average 30 min. Data collected were analyzed from a total of 238 questionnaires (Table 1): 161 Psychology students (67.6%) and 77 Philosophy students (32.4%). 12 questionnaires were removed from analysis since they were completed by students from other academic degrees. Respondents were all undergraduates between 18 and 23 year old (95%, $n = 225$), with the majority of them being first-year (89.9%, $n = 214$), aged 18 to 19 years old (86.5%, $n = 205$). Unsurprisingly enough, the majority

Table 1 The study's sample profile

		Frequency	Percent
Gender	Males	32	13.4
	Females	206	86.6
Department	Psychology	161	67.6
	Philosophy	77	32.4
Study year	1st	214	89.9
	2nd, 3rd, 4th	24	10.1
Age	18	182	76.5
	19	23	9.7
	20	11	4.6
	>20	22	9.0
Total		238	100.0

of the respondents were females (86.6%, $n = 206$) with only a 13.4% males ($n = 32$), following a similar trend in the Greek student population enrolled in these degrees.

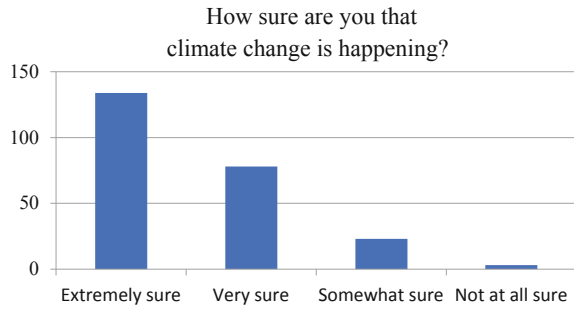
In the following section we present the study's results related to questions surveying the students' beliefs and concerns about climate change, their self-reported knowledge and understandings about how the climate system works, what factors contribute to the global temperature rise (causes), and potential actions that would help mitigate global warming (solutions). Data analysis reported in this paper includes descriptive statistics. Differences in the respondents' answers were found to be non-significant for 'gender' and 'disciplinary field/ Department' variables.

3 Results and Discussion

3.1 Beliefs About Climate Change

The absolute majority of our study's sample believe that climate change is happening (97.9%, $n = 232$) and an equally high percentage confirms that this is beyond any doubt (89.1%, $n = 212$) (Fig. 1). This is in accordance with previous studies, such as the one by Wachholz et al. (2014), reporting that a high percentage of American college students (75%, $n = 255$) believe they are experiencing climate change. A similar certainty about climate change is expressed among almost all postgraduate Portuguese (98%) and Mozambican students (100%) and to a slightly lesser extent among Mexican students (82%) as reported in the studies by Santos et al. (2016) and Morgado et al. (2017). An equally high percentage of Croatian students from the Faculty of Economics and Tourism expressed their certainty about climate change (95%) in the study by Nefat and Benazić (2019). Turkish undergraduate students

Fig. 1 Degree of students' expressed certainty that climate change is real



also confirm that the phenomenon of global warming is real (87.7%) in the study by Ateş et al. (2017).

More than half of the Greek respondents identified climate change as basically a human-induced environmental problem (66%, $n = 157$). This percentage was somewhat higher in the study by Wachholz et al. (2014) addressing American students (78%, $n = 273$); and in the study by Nefat and Benazić (2019) investigating Croatian graduate and undergraduate students (79%). Santos et al. (2016) reported an even higher percentage of Portuguese postgraduate students (96%) who identified climate change as human-induced, and a similar trend was revealed in the results of the study by Arto-Blanco et al. (2017), with most participants considering human agency as the main cause of climate change. As opposed to these results, the study by Díaz Estévez et al. (2014) indicated that only 29.96% among university students of different nationalities (including Spanish and Italian students) recognized an anthropogenic origin in climate change, compared to a much higher percentage (67.98%) who viewed it as the result of a combined nature and human agency. In our study, the respective percentage of Greek students who perceived climate change as being due to both human activities and natural changes was considerably smaller (31.5%, $n = 75$).

Contrary to what other studies report, Greek students in our study believe that there is a high degree of consensus in the scientific community that climate change is real (64.3%, $n = 153$), with only a smaller percentage saying that they perceive a lot of disagreement among scientists (14.3%, $n = 34$) (Fig. 2). This finding offers a more optimistic perspective compared to what, almost one decade ago, studies such as the one by Wachholz et al. (2014) reported about American students. The fact that they framed the very existence of climate change as a matter of controversy among scientists was argued to be the result of a deliberate attempt from the media and specific interest groups to stir up a sense of doubt and denial about the climate issue in public opinion.

Similar trends are shown in previous research, as for example the one by Nefat and Benazić (2019), reporting an even higher percentage of Croatian students (81%) who view that the scientific community is in agreement about climate change. Likewise, the majority of Portuguese students in the study by Santos et al. (2016) expressed their certainty that there is consensus among scientists about climate change (75%).

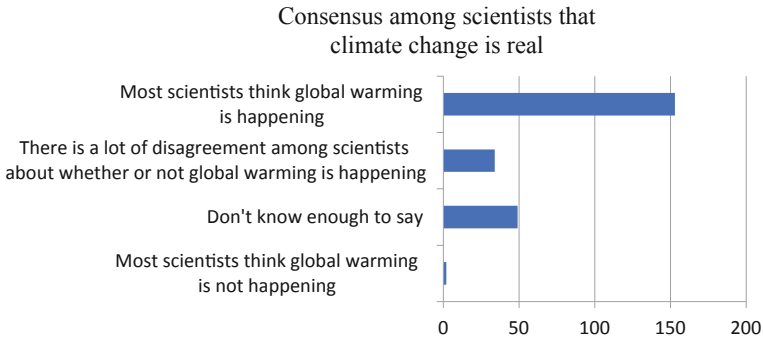


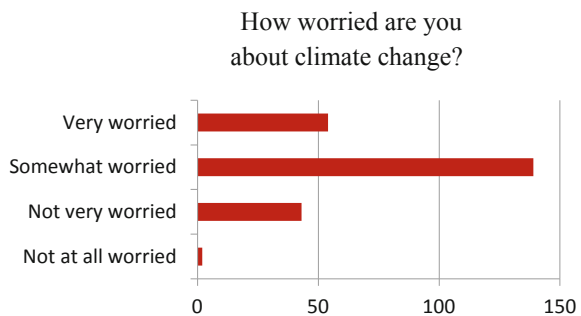
Fig. 2 Students’ beliefs about scientific consensus on climate change

3.2 Concern About Climate Change

Expressed concern about climate change was quite high in our study’s sample (Fig. 3). When asked how worried they felt about climate change, four out of five Greek students (81.1%, n = 193) replied they were either very worried (22%, n = 54) or somewhat worried (58.4%, n = 139). Similar tendencies in the students’ concern, although with slightly lower percentages, were identified in previous studies with American students (Wachholz et al. 2014) or students from other Mediterranean countries (i.e., Cordero et al. 2008; Santos et al. 2016; Morgado et al. 2017; Nefat and Benazić 2019). Nevertheless, almost 20% of the Greek students say they are not particularly worried or not worried at all about climate change, which is quite an alarming figure.

To further explore the students’ concern about climate change, two new questions were posed towards the end of the survey, asking them how they rate the climate issue in terms of seriousness; and how much they had thought and worried about climate change until they completed this questionnaire. In relation to how they rate climate change, the vast majority (94.9%, n = 222) identify it as a highly serious (42.4%, n = 101) or very serious problem (50.8%, n = 121), confirming their previously

Fig. 3 Students’ level of expressed concern about climate change



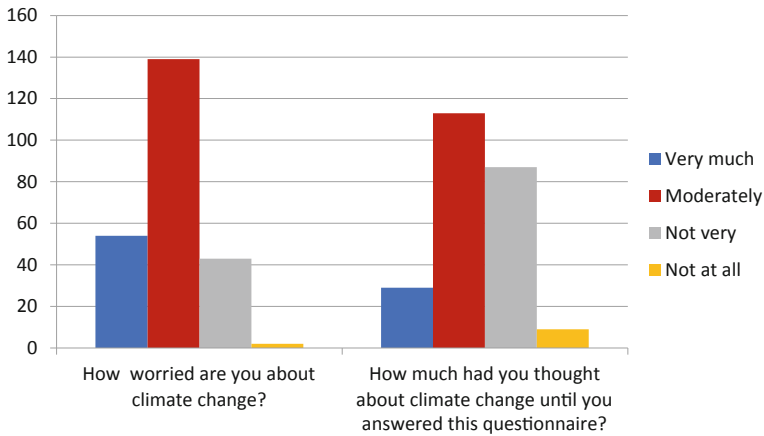


Fig. 4 Students' level of expressed concern about climate change compared to their level of self-reported engagement with the issue prior to questionnaire completion

expressed concern about climate change. In the study by Manolas et al. (2010) study Greek forestry students, when asked to rate the seriousness of the problem also gave a high score. A similar high rate was assigned by the majority of Croatian students in terms of how serious they view climate change as a threat to humankind compared to being a threat to themselves or their families (Nefat and Benazić 2019), and in other studies (Morgado et al. 2017; Wachholz et al. 2014). Nevertheless, when asked again, much fewer students in our study admitted they had thought a lot (12.2%, $n = 29$) or even moderately (47.5%, $n = 113$) about climate change until their participation in the study (Fig. 4).

3.3 Self-reported Knowledge About Climate Change

Students were also asked how knowledgeable they consider themselves to be about various aspects of the climate change issue (Fig. 5). Higher percentages responded they felt confident enough about their knowledge level regarding the various impacts of global warming (81.9%, $n = 184$). However, comparatively fewer students answered the same about their understanding of how the earth climate system works (60.3%, $n = 143$) or about the causes (67.2%, $n = 158$) and potential solutions to reduce the global temperature rise (59.7%, $n = 142$). A similar finding is described in the studies by Santos et al. (2016) and Morgado et al. (2017), in which Portuguese, Mozambican, Mexican samples of students reported a moderate or minimal knowledge of how to deal with climate change. Most Turkish undergraduate students also reported a moderate (49%) to limited (25%) knowledge about the causes and consequences of global climate change (Ateş et al. 2017). Based on results of their cross-national study, Díaz Estévez et al. (2014) argue that university students seem to

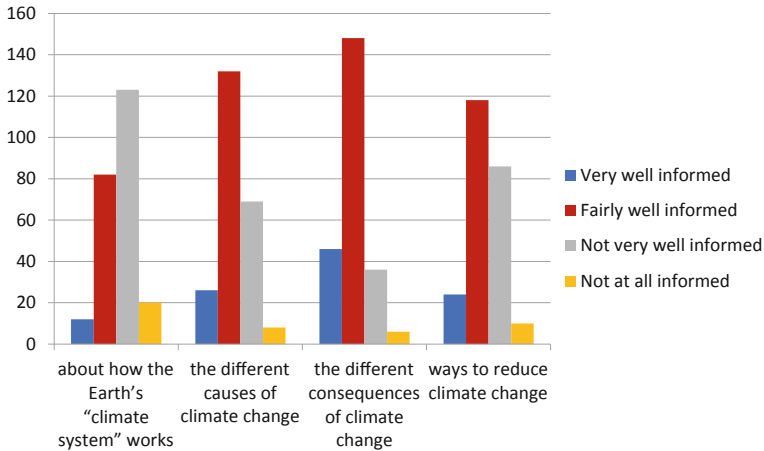


Fig. 5 Level of self-reported knowledge about dimensions of climate change

have a rather superficial knowledge about the causes of climate change. Further to this, Bråten et al. (2009) argued about the cultural embeddedness of climate change knowledge, pointing to the fact that students' beliefs seem to be shaped by the degree, content and emphasis given by public discourse on the topic in different parts of Europe.

The vast majority of our study's sample expressed their need to get more information about the climate change issue (94.1%, $n = 222$). Similar needs were articulated by students in other Mediterranean countries (i.e., Santos et al. 2016; Morgado et al. 2017; Nefat and Benazić 2019) as well as by American students (Wachholz et al. 2014). Finally, although most Greek students agree that both schools and Universities have the responsibility to teach youths about climate change, the majority of students ascribe such a role more to schools (91.6%, $n = 217$) compared to higher education institutions (63.1%, $n = 149$).

3.4 Understanding the Science of Climate Change

3.4.1 Weather Versus Climate

The majority of students correctly understand that weather often changes from year to year (71.7%, $n = 170$) and that 'climate' means the average weather conditions in a region (75.6%, $n = 180$) (Fig. 6). However, almost half the respondents (42.9%, $n = 102$) incorrectly believe that the climate also changes from year to year. In similar percentages students correctly reject the idea that 'climate' and 'weather' mean the same (50.8%, $n = 121$) and correctly understand with a varying degree of confidence that 'weather' does not mean the average climate conditions in a

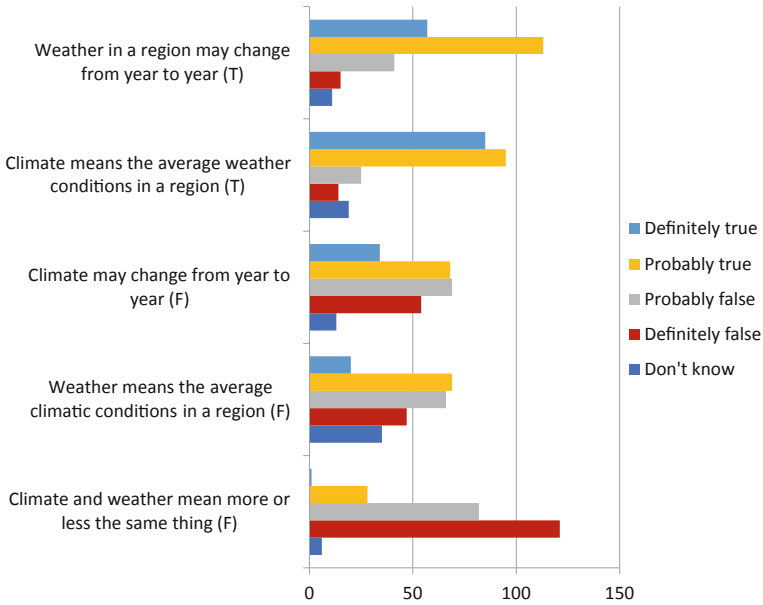


Fig. 6 Students’ level of understanding climate Versus weather

region (47.6%, n = 113), even though 14.8% of them (n = 35) say they do not have sufficient knowledge to identify the correct answer. Research evidence indicates that distinguishing between weather and climate is a challenge and people often encounter difficulties in realizing where the differences between the two lie (Lombardi and Sinatra 2012).

3.5 Understanding of Climate Science Facts

Regarding the students’ understanding of the flow of heat across the planet, only few among them seem to accurately know that ocean currents carry heat from the equator toward the north and south poles (31.1%, n = 74). The majority of students (60.9%, n = 145) cannot discern whether this is correct or not. Much fewer students correctly understand that the atmosphere does not carry heat from the poles (which are cold) towards the equator (which is warm) (18.9%, n = 45), with a high percentage admitting that they don’t know the answer (63.4%, n = 151). In the study by Leiserowitz et al. (2011), Americans provide correct answers to these two questions in slightly higher percentages (54% and 33% respectively).

The majority of our study’s respondents (77.2%, n = 183) correctly understand that the Earth’s climate has not remained the same through the millions of years as outlined by Lamb (1977) among other scholars. They also correctly believe that

climate change has played an important role in the advance or collapse of some past human civilizations (78.5%, n = 186), as many scientists have pointed out, among whom Ellenblum (2012), whose research on how climatic disturbances affected the prosperity or decline of old civilizations in the Mediterranean Basin shed new light on our historic knowledge of the region.

A smaller percentage of Greek students answers accurately that rising levels of carbon dioxide in the atmosphere have caused global temperatures to increase in the past (56.5%, n = 134), although 31.2% (n = 74) say they don't know if this is true or not. 77.2% of the students correctly reject the statement that current global temperature conditions are warmer than in previous periods in the past, while 66.3% rightly affirm that the 2009–2019 decade was the warmest since 1850, although 29.7% say they don't know. Finally, a high percentage of students incorrectly believe that in the past, the Earth's climate always shifted gradually between warm and cold periods (65.5%, n = 154), while 20% (n = 47) says they don't know. The graph in Fig. 7 summarizes the students' responses to each of the above mentioned climate science facts.

Previous research also indicates that even University students (as well as school students) tend to hold conceptions that are not in agreement with scientifically accepted conceptions about how the climate system works (Versprille et al. 2017;

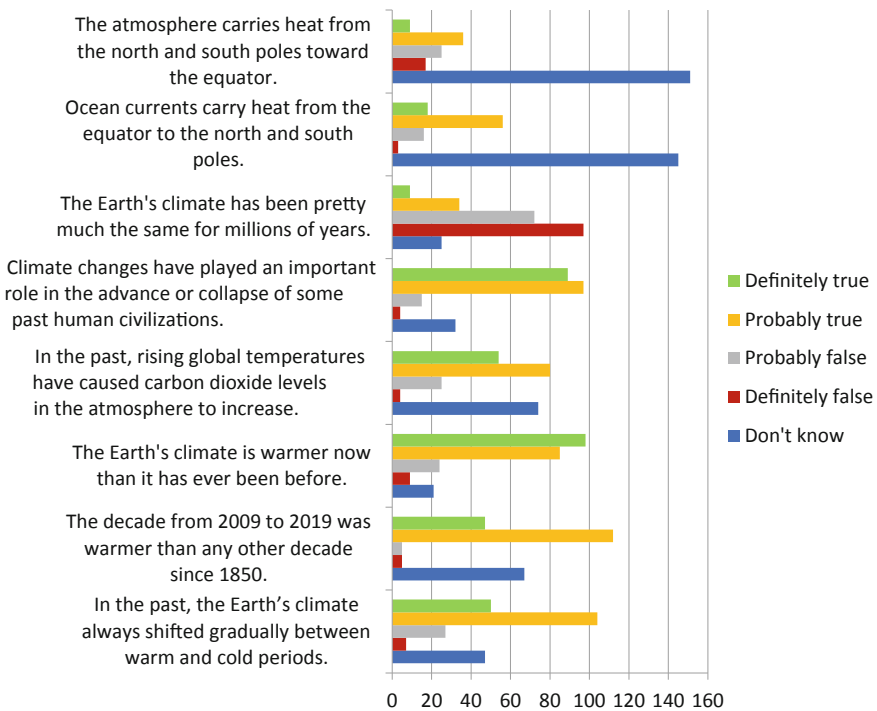


Fig. 7 Students' level of understanding about various 'climate science facts'

Shepardson et al. 2012). As these studies suggest, this may lead to a poor understanding of the phenomena and to a faulty perception of the mechanisms involved. However, the argument put forth by this study points to a different direction, by saying that any of these indications of what students understand about climate change need to be treated cautiously and in conjunction with how research on learning frames them. One such approach, building on Bowen and Rodger (2008), argues that even when the students' knowledge is aligned with what climate scientists claim, students may still lack the necessary "interpretive framework for making sense of the knowledge held" (p. 97).

3.6 Beliefs About Factors Contributing to Global Warming

Respondents in our study were then provided with a list of factors and asked to what degree each of them affects the average global temperature of the Earth. The vast majority (89.8%, $n = 212$) correctly answered that greenhouse gases have a major (47.5%, $n = 112$) or some impact (42.4%, $n = 100$) on it (Fig. 8). Only a very small percentage of students (5.4%, $n = 13$) reported that greenhouse gases affect the Earth's temperature a little or not at all. Other studies with university students in other Mediterranean countries produced similarly high percentages by identifying greenhouse gases, especially car emissions, as the main cause of global temperature rises (Ibrahim et al. 2018). In the study by Arto-Blanco et al. (2017) 42.8% of Spanish students related greenhouse emissions primarily to the use of automobiles although they tended to attribute a higher degree of causality to industrial pollution (50.7%). Greek forestry students also singled out greenhouse gases as the main factor contributing to global warming, distinguishing between emissions resulting from industrial activity (mean 8.60) and transportation (mean 6.38) (Manolas et al. 2010).

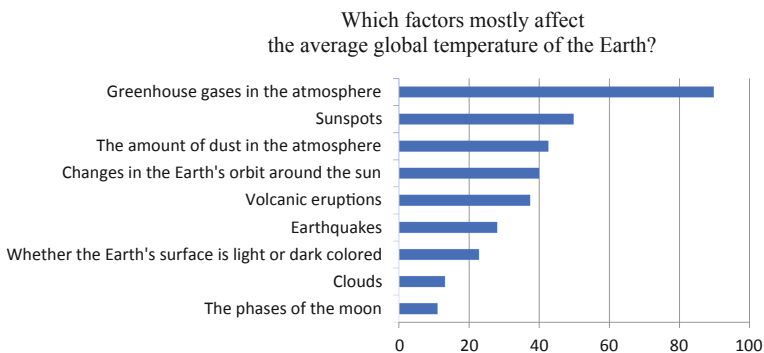


Fig. 8 Students' beliefs about the factors that mostly affect the average global temperature of the Earth

Regarding other factors with a contribution to global warming, Greek students' beliefs were mixed to a greater or lesser extent. For example, those who correctly understand that sunspots affect the Earth's temperature are higher (49.8%) compared to those who wrongly believe they do not (13.3%). Students' responses are divided between those who correctly believe that changes in the Earth's orbit around the sun affect the global Earth temperature (39.5%) and those who think this is false (33.5%). A slightly higher percentage of students correctly understand that the amount of dust in the atmosphere has some impact on the temperature of the Earth (42.6%) compared to those who wrongly believe there is little or no impact at all (35.3%).

On the other hand, significantly more are those who falsely think that clouds do not have some kind of contribution to global warming (57.3%) compared to those who correctly believe they do (13.1%). Similar tendencies, although with a less sharp gap, are indicated between those who wrongly believe that volcanic eruptions do not affect the Earth's temperature (46%) compared to those who correctly believe they do (37.4%); and between those who wrongly say that light or dark colored Earth surface areas have no impact on global temperature (31.9%) compared to those who correctly identify there is (22.8%). Those who correctly see no connection between earthquakes and the rise of global Earth temperature are almost half the sample (46.6%) compared to a much smaller percentage who incorrectly believes there is some connection (28%). Likewise, more students correctly reject that the phases of the moon have some kind of an impact on the global temperature (38.4%) compared to those who falsely believe they do (11%).

However, the study indicates that there are many knowledge gaps in the students about the possible contributors to the Earth's global temperature. Apart from identifying the role of the greenhouse gases, comparatively high numbers of students admit they don't know enough to say whether the lightness/darkness of the Earth's surface areas (45.1%) or sunspot phenomena (36.2%) have any kind of contribution; whether atmospheric clouds can trap the heat beneath them (29.3%); what the actual responsibility share for any changes in the Earth's orbit around the sun is (27%); whether earthquakes (25.3%) or the amount of dust in the atmosphere (21.5%) have any impact; and what the role of volcanic eruptions (16.2%) in affecting global temperature is.

Misconceptions about what causes global temperature rise have also been reported in previous studies conducted with university students samples (i.e., Cordero et al. 2008; Kerr and Walz 2007; Khalid 2003; Morgan and Moran 1995; Wilson and Henson 1993; Wachholz et al. 2014). Although most Greek students in our study seem to recognize that greenhouse gases have a major contribution to global warming compared to what, for example, the study by Wilson and Henson (1993) reported with a US sample more than two decades ago, several false conceptions or uncertainties still exist. The fact that respondents are less knowledgeable about the natural causes of climate change is supported by Lorenzoni et al. (2007), arguing that most people tend to believe that climate change is mostly caused by anthropogenic and natural causes although they do not understand the details. Moreover, findings based on the study by Morgado et al. (2017) indicate that students are more able to understand causes stemming from individual behaviors instead of natural causes. Nevertheless,

it is worth keeping in mind what Díaz Estévez et al. (2014) turned our attention to, which is that university students seem to have a superficial knowledge of the causes of climate change, despite the fact that climate change is part of a global culture and intrinsically related to the values that define this generation's interests.

3.7 Beliefs About Actions to Mitigate Global Warming

The majority of our study's respondents (92.3%, $n = 216$) correctly understand that if the switch from fossil fuels to renewable energy sources were applied as a universal measure, there would be a considerable reduction in the global temperature of the Earth. When asked for a second time to select only one option from a list that would do the most to reduce global warming, again switching from fossil fuels to renewable energy sources was by far the one selected by most students (58.1%, $n = 137$).

Planting trees is another action a high percentage of students (88%, $n = 206$) correctly consider that has a positive impact on mitigating climate change and the same applies to measures attempting to diminish tropical deforestation (87.6%, $n = 205$) or aim to switch from gasoline to electric cars (88.5%, $n = 207$). Driving less is also identified by a high percentage of students as a solution (71.5%, $n = 168$), while 63.2% believe that increasing public transportation would reduce global warming ($n = 148$). Half of the participants believe that switching from regular incandescent to compact fluorescent bulbs (52.3%, $n = 123$) has some kind of contribution to reducing global temperature. Fewer think that insulating buildings may have a positive impact (30.3%, $n = 71$) compared to those who do not believe this would be of some use (38.9%, $n = 91$). A similar tendency is observed in students correctly saying that switching from fossil fuels to nuclear power would be a solution (29.9%, $n = 70$) compared to those who disagree with this (33.8%, $n = 79$).

On the other hand, a high percentage of students incorrectly believe that reducing toxic waste would have a positive impact on climate change (89.7%, $n = 210$). This misconception is also reflected in the percentage of students choosing this as the best option from a list of factors reducing global warming (14.4%, $n = 34$), although with a great distance from those who select switching from fossil fuels to renewable energy sources (58.1%, $n = 137$) (Fig. 9). Another misconception is identified when more than half of the students incorrectly believe that banning aerosol spray cans would reduce global warming (61.5%, $n = 144$). More studies have identified that young people often link several environmental problems, pollution in particular, with anthropogenic climate change (Andersson and Wallin 2000; Pekel and Özay 2005).

Respondents are divided among those who do believe that placing a large tax on all fossil fuels would lower global warming (50.9%, $n = 119$) and those who do not (37.2%, $n = 87$) or do not know (12%, $n = 28$). A high enough percentage (76.1%, $n = 178$) disagrees that the option of having at most 2 children per family would be a solution. A similar trend in the Greek students' perception is indicated in relation to the option of immediately stopping the consumption of red meat, with more than

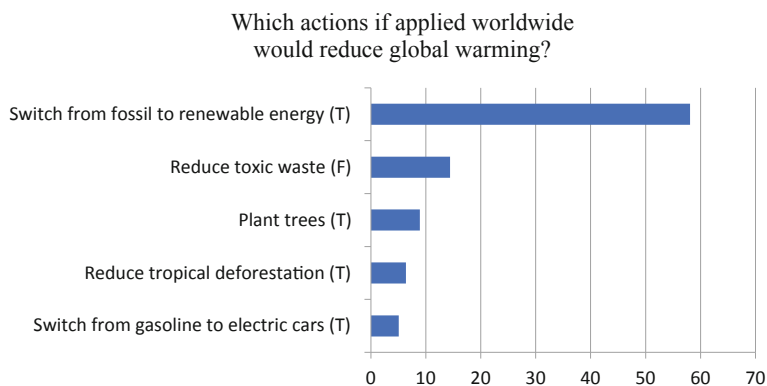


Fig. 9 The top 5 actions students believe would reduce global warming if applied worldwide

half of the respondents rejecting it (60.4%, $n = 142$) and a quite steeper percentage admitting they don't know about it (22.1%, $n = 52$).

Previous studies have reported similar tendencies in the university students' perception of the factors contributing to climate change which are at the same time part of the solutions to it. For example, in the study by Manolas et al. (2010), Greek forestry students rated higher human actions and policies aiming to regulate the production of greenhouse gases at the level of industrial activity, deforestation, energy production and transportation. Respectively, they rated lower the possibility of taking measures such as central heating installations, global population rise, household waste dumps and agricultural activity.

In another study (Santos et al. 2016), Portuguese students expressed their willingness to support specific measures to reduce greenhouse gases (57%), including paying more for fuel and electric energy, although 31% were not sure about it and 13% would not support such actions. Among the proposed mitigation measures would be reducing the use of cars and fossil fuels and sharing the car with friends and colleagues (24%), increasing recycling and the reutilization of materials, such as the use of plastic bags (18%), as well as cutting down energy (18%) and water consumption (10%). Other measures proposed by smaller percentages of students were raising the environmental awareness of people close to them (8%), lessening meat consumption (7%), promoting local products (4%), and engaging in nature conservation activities and the planting of trees (3%).

4 Conclusions

The study reported here was carried out with a sample of first-year undergraduate students enrolled in two academic programs of the Faculty of Social Sciences and Humanities at the National and Kapodistrian University of Athens (NKUA). Being

part of a wider research project aiming to explore the climate change literacy and learning profiles of the NKUA students across a range of disciplinary fields, this study offers a glimpse of how Greek University students with a non-science disciplinary background perceive, understand and feel about climate change. The aim for conducting this survey was twofold: to contribute with new empirical data to a scant but continuously growing research area on university students' beliefs, concerns and understandings of climate change, both at a national and international level, with a special focus on the Mediterranean region; and to inform future decision-making about whether and how to integrate new CCE courses into the curricula of particular academic programs of study.

Data were collected with the use of a questionnaire, which was closely modeled on the survey instrument developed by Leiserowitz et al. (2011) from the Yale Project on Climate Change Communication team. Data analysis focused on exploring the students' beliefs and concerns about climate change, and demonstrated their self-reported knowledge and understandings about some basic climate science concepts and facts, and the causes and actions against global warming. The main study's results are summarized below:

- Almost all students believe that climate change is occurring and that it is a fact beyond any doubt. More than half of the respondents identify climate change as basically a human-induced problem and think that there is consensus among scientists on this. A large majority perceives climate change as an alarming problem with most students feeling worried about it to a moderate or high degree.
- Even though most students declare themselves confident regarding their knowledge about climate change, many of them admit they have a less accurate understanding of how the Earth's climate system works or the causes and potential solutions to climate change. At the same time, the vast majority expresses their need to get more information about the causes, impacts and possible solutions to climate change, while they also recognize that this role pertains primarily to schools and next to Universities.
- In terms of their understanding of some basic climate science concepts and facts, most students are successful in distinguishing between climate and weather although some still encounter difficulties. The same applies to perceiving that climate conditions had been changing along human history although not in similar patterns as currently; and that climate has been a decisive factor in shaping culture and history. Their accuracy in understanding is even less acute in relation to other climate science claims, such as the heat flow channels across the planet.
- In terms of the factors causing global temperature to rise, a large majority of students correctly identify greenhouse gases. Many, though, hold misconceptions or feel uncertain to a greater or lesser degree about the role of other factors, especially nature-related ones, such as sunspots, the Earth's orbit around the sun, the amount of dust in the atmosphere, colored Earth surface areas, and volcanic eruptions. There are also students who mistakenly view others factors, such as earthquakes or the phases of the moon, as impacting global temperature although they don't.

- The large majority of students recognize that switching from fossil fuels to renewable energy sources would be a solution to the problem. Planting trees, reducing tropical deforestation, switching from gasoline to electric cars, driving less and increasing public transportation are among the actions identified by students as having a positive impact on mitigating global warming. However, many students fail to perceive that actions like switching to compact fluorescent bulbs, domestic insulation or nuclear power would contribute too. Misconceptions regarding the role of measures such as reducing toxic waste or banning aerosol spray cans show that they still hold strong among this sample. Finally, students feel ambivalent about whether the adoption of fiscal measures, birth control, or changes in dietary habits could help mitigate climate change.

Extended scientific evidence asserts that anthropogenic climate change is occurring and that it represents one of the greatest challenges of our times (Hansen and Stone 2016). This study's findings are in accordance with previous studies (Feldman et al. 2010; Morgado et al. 2017; Santos et al. 2016; Wachholz et al. 2014), showing that Greek students are along the same line of thought: they do perceive climate change as a real and largely human-induced problem. They also feel concerned about climate change and acknowledge it as a major current issue. Moreover, contrary to previous studies (Wachholz et al. 2014; Morgado et al. 2017), Greek respondents do not endorse inconsistent views about lack of consensus among the scientific community on climate change, which is another promising fact. However, since high levels of awareness and concern do not always correspond to high levels of knowledge, Greek students admit they lack important knowledge about various aspects of the climate change issue and express their need to develop a better understanding of them. The students' openness and willingness to learn more about climate change combined with their high levels of awareness and concern about the issue confirms that CCE has a place in the curricula of at least these two degrees (Psychology and Philosophy) and possibly in more academic areas from the Social Sciences and Humanities.

Knowledge gaps are identified by the students themselves on fundamental climate science information that would allow them to understand how the climate system works, and on more socially-driven inputs and perspectives, such as climate change causes and solutions. Our study also confirms the existence of a certain degree of confusion, uncertainty or lack of knowledge among students, such as in relation to 'weather versus climate' (Lombardi and Sinatra 2012) or specific climate science facts and claims (Versprille et al. 2017; Shepardson et al. 2012). Apart from that almost all students identify greenhouse gases as the main cause of global warming, they seem bewildered to a greater or lesser extent about the role of other factors, with many of the respondents holding inaccurate conceptions about them. The same applies to how they approach actions of mitigation, with, again, the majority of them feeling more confident about options leading to a more fossil fuel-free and energy-saving society. However, they stand indecisive in front of more options or tend to reject some of them, probably out of the nuanced frames they have developed about other environmental issues (such as nuclear power or toxic pollution) or based on

their negatively biased perceptions about certain individual or social activities (such as driving less, excluding red meat from diet, or promoting birth control).

However, what is important to keep in mind is that many of these misconceptions and biases stem from the inherent complexity and the accompanying uncertainty climate change induces as a 'wicked problem' (Incropera 2016). Kollmus and Agyeman (2002) are quite explicit arguing that climate action, as any other environmental actions, is grounded on a combination of fundamental scientific knowledge, pro-environmental attitudes and emotional involvement about the issue, all shaped by the individuals' values and norms and influenced by a range of socio-psychological parameters and external contextual factors, intervening to affect a climate-specific consciousness and decision-making. Moreover, scant understanding and skepticism about climate change are identified among the main barriers impeding the students' engagement with climate action (Lorenzoni et al. 2007). An action competence approach (Jensen and Schnack 1997) that focuses on facilitating students to overcome such barriers through critical reflection and by integrating climate action in their everyday and local activities and in their future professional practices, through learner-centered, action-oriented, and transformative pedagogies, can be an appropriate frame for CCE in Higher Education institutions. Such considerations have to be taken into account when thinking about how research findings can inform the design of CCE opportunities at this level.

A final note on the limitations this study raises is shared here. One such limitation concerns the tool employed for collecting data on Greek university students' beliefs, concerns and understandings of climate change. The choice of using a questionnaire closely modeled on the one developed by the Yale Project on Climate Change Communication was deliberate, based on the criteria that (a) it was singled out as a reliable survey instrument, which also provided access to the correct answers, all supported by well-established scientific evidence; and (b) it allowed for a large-scale assessment among hundreds of respondents and the possibility to compare results with those of other studies following a similar methodology. However, one consequence of this choice is that the students' beliefs, concerns and understandings are restricted by the content of this questionnaire, with possibly other relevant aspects and nuances of the topic, which might have been captured through a different methodology, to be left out. It is therefore argued that future research should be based on a multi-method research design, combining a large-scale, quantitative approach with more, small-scale case studies of a qualitative perspective.

A second limitation of the study is that the results are not generalizable to the overall student population either on a national or an institutional level. It is thus relevant that future research addresses student samples from other Faculties, degrees and programs of academic study at the NKUA as well as other Greek HE institutions. A comparative study among students of various profiles would also be meaningful to determine statistically significant differences. 'Disciplinary field of study', 'age', 'year *or* level of study' and 'gender' are some profiling variables that need to be more thoroughly investigated as to whether they can explain statistical variance in Greek students' beliefs, concerns and understandings of climate change. Although such statistical analyses were beyond the scope of the study reported here, which

was mainly of a descriptive nature, it is deemed important to take more than one of these variables into account in the selection and composition of the sample in future research and in order to avoid various biases, such as the gender bias related to certain degrees that concentrate higher numbers of either male or female students. Finally, a more culturally-oriented and sensitive research design would allow us to explore more thoroughly and explain climate change beliefs and understandings within the NKUA students population or across different university samples, both on a national and cross-national level, including the various Mediterranean countries.

Addressing climate change at the Universities is an imperative for CCE (Leal Filho et al. 2018; Leal Filho and Hemstock 2019), not only to raise awareness among students but also to promote ways to build new and sound interdisciplinary knowledge, to critically refute an incomplete and faulty one, and to empower students to act on it. This applies to all countries of the Mediterranean Basin sharing a region that is particularly prone to be affected by the impacts of actual and future climate changes (Ozturk et al. 2015; Cramer et al. 2018), including Greece. Addressing this goal needs to be based on a research-based comprehension of how students across a range of disciplinary fields perceive and understand climate change; and use this knowledge as a starting point to further explore the barriers impeding learning about climate change as well as the educational strategies to overcome them (Azeiteiro and Leal Filho 2017). Our study points to that direction, by bringing to the fore how Greek students from the Social Sciences and Humanities view and understand climate change. Although not generalisable to the overall population, the study's results provide useful insights about the necessity, readiness and possible routes for incorporating CCE into the academic curricula of these disciplinary fields in Greece as well as opening up the discussion about similar endeavors in other Mediterranean countries.

References

- Andersson B, Wallin A (2000) Students' understanding of the greenhouse effect, the societal consequences of reducing CO₂ emissions and the problem of ozone layer depletion. *J Res Sci Teach: Offic J Nat Assoc Res Sci Teach* 37(10):1096–1111
- Arto-Blanco M, Meira-Carrea PÁ, Gutiérrez-Pérez J (2017) Climate literacy among university students in Mexico and Spain: influence of scientific and popular culture in the representation of the causes of climate change. *Int J Glob Warm* 12(3–4):448–467
- Ateş D, Teksöz G, Ertepinar H (2017) Exploring the role of future perspective in predicting Turkish university students' beliefs about global climate change. *Discourse Commun Sustain Educ* 8(1):32–52
- Azeiteiro UM, Leal Filho W (eds) (2017) Climate literacy and innovations in climate change education. *Int J Glob Warming*. Inderscience Publishers. IF 1.043 (2015/16) Q2
- Ballew MT, Leiserowitz A, Roser-Renouf C, Rosenthal SA, Kotcher JE, Marlon JR, Lyon E, Goldberg MH, Maibach EW (2019) Climate change in the American mind: Data, tools, and trends. *Environ: Sci Pol Sustain Dev* 61(3):4–18
- Bowen GM, Rodger V (2008) Debating global warming in media discussion forums: strategies enacted by persistent deniers and implications for schooling. *Can J Environ Educ* 13(1):89–106

- Boyes E, Chuckran D, Stanisstreet M (1993) How do high school students perceive global climatic change: what are its manifestations? What are its origins? What corrective action can be taken? *J Sci Educ Technol* 2(4):541–557
- Bråten I, Gil L, Strømsø HI, Vidal-Abarca E (2009) Personal epistemology across cultures: exploring Norwegian and Spanish university students' epistemic beliefs about climate change. *Soc Psychol Educ* 12(4):529–560
- Cordero EC, Todd AM, Abellera D (2008) Climate change education and the ecological footprint. *Bull Am Meteor Soc* 89(6):865–872
- Corner A, Roberts O, Chiari S, Völler S, Mayrhuber ES, Mandl S, Monson K (2015) How do young people engage with climate change? The role of knowledge, values, message framing, and trusted communicators. *Wiley Interdisc Rev: Clim Change* 6(5):523–534
- Cramer W, Guiot J, Marini K (2018) Risks associated to climate and environmental changes in the Mediterranean Region. *MedECC Report*
- Dawson V (2015) Western Australian high school students' understandings about the socioscientific issue of climate change. *Int J Sci Educ* 37(7):1024–1043
- Díaz Estévez M, de Frutos García RA, Peña Moya J (2014) Communication of the scientific consensus on climate change to the citizenship: knowledge and perception of young university students from five countries regarding the media treatment of global warming. *Interactions: Stud Commun Cult* 5(1):51–70
- Ellenblum R (2012) The collapse of the eastern mediterranean: climate change and the decline of the east, 950–1072. Cambridge University Press, Cambridge
- Feldman L, Nisbet MC, Leiserowitz A, Maibach E (2010) The climate change generation. Survey analysis of the perceptions and beliefs of young Americans. Yale Project on Climate Change & George Mason University Center for Climate Change Communication
- Hansen G, Stone D (2016) Assessing the observed impact of anthropogenic climate change. *Nat Clim Chang* 6(5):532–537
- Hermans M, Korhonen J (2017) Ninth graders and climate change: attitudes towards consequences, views on mitigation, and predictors of willingness to act. *Int Res Geograph Environ Educ* 26(3):223–239
- Ibrahim AA, Fahmy HD, Mahmoud SR (2018) Knowledge and attitude regarding global warming phenomenon among Assiut University Students. *Assiut Sci Nurs J* 6(14):1–11
- Incropera FP (2016) Climate change: a wicked problem: complexity and uncertainty at the intersection of science, economics, politics, and human behavior. Cambridge University Press, Cambridge
- Jackson L, Pang MF (2017) Secondary school students' views of climate change in Hong Kong. *Int Res Geograph Environ Educ* 26(3):180–192
- Jensen BB, Schnack K (1997) The action competence approach in environmental education. *Environ Educ Res* 3(2):163–178
- Kerr SC, Walz KA (2007) “Holes” in student understanding: addressing prevalent misconceptions regarding atmospheric environmental chemistry. *J Chem Educ* 84(10):1693–1696
- Khalid T (2003) Pre-service high school teachers' perceptions of three environmental phenomena. *Environ Educ Res* 9(1):35–50
- Kollmuss A, Agyeman J (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ Educ Res* 8(3):239–260
- Lamb HH (1977) Climate. Present, past and future - Volume. 2: Climatic history and the future. London, Methuen
- Leal Filho W (ed) (2010) Universities and climate change: introducing climate change to University Programmes. Springer, Berlin
- Leal Filho W, Hemstock SL (2019) Climate change education: an overview of international trends and the need for action. In: Leal FW, Hemstock S (eds) Climate change and the role of education. Springer, Cham, pp 1–17

- Leal Filho W, Morgan EA, Godoy ES, Azeiteiro UM, Bacelar-Nicolau P, Ávila LV, Mac-Lean C, Hugé J (2018) Implementing climate change research at Universities: barriers, potential and actions. *J Cleaner Prod* 170:269–277
- Leiserowitz A, Smith N, Marlon JR (2011) American teens' knowledge of climate change. Yale University. Yale Project on Climate Change Communication: New Haven, CT
- Lombardi D, Sinatra GM (2012) College students' perceptions about the plausibility of human-induced climate change. *Res Sci Educ* 42(2):201–217
- Lorenzoni I, Nicholson-Cole S, Whitmarsh L (2007) Barriers perceived to engaging with climate change among the UK public and their policy implications. *Glob Environ Chang* 17(3–4):445–459
- Manolas EI, Tampakis SA, Karanikola PP (2010) Climate change: the views of forestry students in a Greek university. *Int J Environ Stud* 67(4):599–609
- Molthan-Hill P, Worsfold N, Nagy GJ, Leal Filho W, Mifsud M (2019) Climate change education for universities: a conceptual framework from an international study. *J Clean Prod* 226:1092–1101
- Morgado F, Bacelar-Nicolau P, von Osten JR, Santos P, Bacelar-Nicolau L, Farooq H, Alves F, Soares AM, Azeiteiro UM (2017) Assessing university student perceptions and comprehension of climate change (Portugal, Mexico and Mozambique). *Int J Clim Change Strateg Manage* 9(3):316–336
- Morgan MD, Moran JM (1995) Understanding the greenhouse effect and the ozone shield: an index of scientific literacy among university students. *Bull Am Meteor Soc* 76(7):1185–1190
- Nefat A, Benazić D (2019) The student perceptions, concern and knowledge with regard to climate changes in Croatia. *Ekonomski Pregled* 70(5):723–742
- Ojala M (2020) To trust or not to trust? Young people's trust in climate change science and implications for climate change engagement. *Children's Geographies*, pp 1–7
- Ozturk T, Ceber ZP, Türkeş M, Kurnaz ML (2015) Projections of climate change in the Mediterranean Basin by using downscaled global climate model outputs. *Int J Climatol* 35(14):4276–4292
- Pekel FO, Özay E (2005) Turkish high school students' perceptions of ozone layer depletion. *Appl Environ Educ Commun* 4(2):115–123
- Santos PT, Bacelar-Nicolau P, Pardal MA, Bacelar-Nicolau L, Azeiteiro UM (2016) Assessing student perceptions and comprehension of climate change in Portuguese higher education institutions. In: Filho WL, Adamson K, Dunk R, Illingworth S, Azeiteiro UM, Alves F (eds) *Implementing climate change adaptation in cities and communities integrating strategies and educational approaches*. Springer, Basel, pp 221–236
- Shepardson DP, Niyogi D, Roychoudhury A, Hirsch A (2012) Conceptualizing climate change in the context of a climate system: implications for climate and environmental education. *Environ Educ Res* 18(3):323–352
- Skamp K, Boyes E, Stannistreet M (2009) Global warming responses at the primary secondary interface. 1. Students' beliefs and willingness to act. *Aust J Environ Educ* 25:15–30
- Skanavis C, Kounani A, Ntountounakis I (2017) Greek universities addressing the issue of climate change. In: Leal Filho W (ed) *Climate change research at universities: addressing the mitigation and adaptation challenges*. Springer, Cham, pp 333–344
- Smith N, Joffe H (2013) How the public engages with global warming: a social representations approach. *Public Underst Sci* 22(1):16–32
- Stevenson KT, Peterson MN, Bondell HD (2016) The influence of personal beliefs, friends, and family in building climate change concern among adolescents. *Environ Educ Res* 25(6):832–845
- UNESCO (2017) *Changing minds, not the climate: the role of education*. UNESCO, Paris
- UNFCCC (2015) *Adoption of the Paris agreement*. 21st conference of the Parties. UN, Paris
- Versprille A, Zabih A, Holme TA, McKenzie L, Mahaffy P, Martin B, Towns M (2017) Assessing student knowledge of chemistry and climate science concepts associated with climate change: Resources to inform teaching and learning. *J Chem Educ* 94(4):407–417
- Wachholz S, Artz N, Chene D (2014) Warming to the idea: university students' knowledge and attitudes about climate change. *Int J Sustain High Educ* 15:128–141
- Weber EU, Stern PC (2011) Public understanding of climate change in the United States. *Am Psychol* 66(4):315

- Whitmarsh L, Capstick S (2018) Perceptions of climate change. In: Clayton S, Manning C (eds) *Psychology and climate change*. Academic Press, London, pp 13–33
- Wilson K, Henson B (1993) *Learning about global warming: a study of students and journalists*. Learning about science easily and readily series. Boulder CO, National Centre for Atmospheric Research