Social representations of climate change in a group of college students from the University of Santiago de Compostela: common culture vs. scientific culture[1]

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ABSTRACT

College students are a sector of the population that is called to play a fundamental role in the future societies. This responsibility with and for society cannot obviate humanity's main challenge nowadays, the anthropogenic climate change. To this end, it is necessary to understand the climatic problem in all its dimensions, in order to propose and accept strategies and measures of adaptation and mitigation. In this paper we present a research on college students of the Universidade de Santiago de Compostela (N = 644). A closed-end questionnaire was used to explore college students´ climate literacy level. Outcomes were compared according to academic discipline and year course. There were statistically significant differences in the distributions of responses (ANOVA) between areas of knowledge and of university degree fields. Nevertheless, in the case of comparing 1st year students with 4th year students there is not statistical significance. Outcomes suggest that most of the information with which college students build their representation of climate change comes from their stage in secondary education and experiences out of the educational system.

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INTRODUCTION

Scientific literacy, understood as dissemination of knowledge and skills produced in the scientific field, has a relatively long history. Its conceptualization and models oscillate between two approaches in order to incorporate it into school curricula. The first approach emphasizes the necessity of guiding teaching and learning processes towards the broadcasting of scientific content, in other words, rigorous transfer of knowledge generated in the scientific field to the society. The second approach opts to focus on educational action within life situations and significant problems in which science plays a key role for understanding and making informed decisions.

This first view assumes that whether people achieve strict scientific knowledge, they will be able to apply it in their daily lives; they will be able to rationally solve problems in their own contexts, assuming the fact that accumulating scientific knowledge has a directly influence on personal decisions and behaviors. This approach usually ignores how people interpret the world and act on it, as well as the role played by a set of individual variables —attitudes, values, emotions, interests, etc.— and contextual variables —social representations and roles, stereotypes and forms of cultural cognition, relationships, situational and identity factors, etc.— (Bybee & McCrae, 2011).

In 2006 the Programme for International Students Assessment (PISA) tried to combine both approaches by incorporating the attitudinal dimension in the assessment of scientific literacy. From this point of view, PISA defines scientific literacy as “the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen” (Schleicher, Zimme, Evans, & Clements, 2009, p.128). According to these authors this functional capacity has three components: scientific knowledge refers to scientific contents and its usefulness to produce new knowledge, understand natural phenomena and offer conclusions based on scientific evidence —metascience or the epistemological dimension—; being aware of how science and technology transform the material, cultural and intellectual environments —the cultural dimension—; and, the willingness to engage in scientific tasks and their ideas as a committed, constructive and reflective citizen —social and political dimension—.

Thereby, the PISA test incorporated four interrelated dimensions oriented towards an integrated assessment of the school population´s scientific literacy: a *contextual dimension*, related to the recognition of everyday life situations that include science and technology; one dimension corresponding to *scientific knowledge* which refers to both knowledge of science —knowledge about the natural world— and knowledge about science itself; a *competence dimension*, which includes identification and explanation processes of issues related to science and the usefulness of scientific basis for argumentation, obtaining conclusions and making decisions; and finally, an *attitudinal dimension*, related to interest and motivation for scientific reasons.

This assessment is carried out through a test in which items are grouped into units where “The focus is on situations in which applications of science have particular value in improving the quality of life of individuals and communities” (Schleicher et al., 2009, p. 146) through scientific content —knowledge "of" and "about" science— and expression of attitudes —concern, support for research and sense of responsibility—.

However, some authors such as González-Gaudiano (2012) do not exactly agree with this change of view toward a more attitudinal approach in favour of reaching scientific/climate literacy by the Organisation for Economic Co-operation and Development (OECD). He questions the idea of introducing scientific content in education as a solution to the climate problem, since "scientific information on climate change is necessary, but not enough to spur social action" (p. 1039). González-Gaudiano supports his argument in an article published by the OECD (2009) in which it states that 15-year-old adolescents who best know the environmental issues in the PISA test, and who are able to explain and transfer their knowledge to other contexts of their daily lives, do not present the supposed "correspondence" attitude and responsibility in mitigation and adaptation to climate change. This disengagement between attitudes and climate literacy confirms "the sad paradox" that the most educated citizens are those with the greatest environmental impact in the global environment. Kahan et al. (2012) defend similar arguments by stating that "public figures with a higher level of scientific literacy and better technical reasoning skills are not the ones who are most concerned about climate change" (p.732).

Furthermore, studies on environmental literacy, such as those by Bradley, Waliczek & Zajicek, (1999) or McMillan, Wright & Beazley (2004), suggest that a better knowledge about the environment correlates with a more pro-environmental attitude and better behavior. Despite that, they suggest the need to find a balance between the three components: conceptual, attitudinal-affective and behavioral, in consideration of the fact that any learning process is very complex, submitting a relationship between cognitive, affective and behavioral components.

Other authors (Busch & Román, 2017; Norris & Philips, 2003) focus their arguments on the very meaning of the term literacy as "the ability to read and write" (Collins, 2005). They support the fundamental dimension of scientific literacy as based on teaching and learning to read, which makes it possible to evaluate and produce scientific texts. It means that having developed this skill a scientifically literate citizen should be able to distinguish biased or erroneous information in a way that those who are not scientifically literate cannot. Accordingly, scientifically literate folks can offer arguments to support their agreement or disagreement with information received in order to make informed and responsible decisions.

This definition of scientific literacy supposes two pedagogical and didactic challenges. On one hand, scientific texts differ from other types of texts in three essential elements that make their interpretation more difficult for technically uneducated people or even non-specialists: technicalities, abstraction and lexical density. On the other hand, it is impossible to keep scientific education and information received separate from other personal components ―prejudices, beliefs, emotions, etc.― and social components ―cultural cognition, social representations, interests, identity, etc.―. Furthermore, epistemological requirements associated with the scientific method and the scientific field are extremely difficult to apply to everyday life, where the common culture, or the "profane culture" as Moscovici would say (1979, p.89), always represent a powerful interpretative and pragmatic framework, even for those people who dominate epistemic codes of science.

Climate literacy definition is highly controversial and is especially intense in the United States. Dupigny-Giroux (2010, p.1203) emphasizes that since 2000 "geoscientific literacy has emerged as a particular area of interest and concern within the larger framework of scientific literacy". This vision contemplates a variety of "scientific literacies": oceanic literacy, earth science literacy, atmospheric science literacy and climate literacy. Thereby, climate literacy appears to be a distinguishable subset within scientific literacy. Climate literacy focus on social spreading of knowledge about climate sciences, their dynamics and relations within atmosphere or terrestrial and oceanic systems on different spatial and temporal scales among other aspects of the phenomenon. González-Gaudaino & Meira (2009) assert that due to this perspective, which demands promotion of a scientific culture emphasized on climate, educational programs have based curricular transposition — ethically neutral and aseptic diffusion of scientific content— on an "updated version" of the science. This new version arises from logical positivism and focuses on the transmission of information and knowledge in the field of ecology and physical-chemistry.

We do not intend to devalue or delegitimize scientific literacy, or climate literacy, as an important constituent of curricula. Nevertheless, Kahan et al. (2012) suggest that concern about climate change seems not to be directly related to a higher level of scientific knowledge. Consequently, some authors (Stevenson, Nicholls, & Whitehouse, 2017) claim that it is necessary to face the challenge of incomplete knowledge without diminishing the imperative need for teachers and students to co-learn and engage in critical thinking and acting in the transition towards a truly sustainable future and a global eco-citizenry.

From this perspective, it should be transforming climate literacy and climate education into an *Education for Climate Change* which takes responsibility for integrating scientific knowledge with other types of available knowledge and representations in order to teach how human societies are modifying the climate and their capacity to act accordingly. In any case, definitions of "climate literacy" such as the one suggested by Dupigny-Giroux (2010) focus on the educational task almost exclusively in the domain of scientific representation, with the utopian expectation of transforming citizens into specialized and highly qualified scientists. This point of view places literacy achievement at an unattainable level for most of the population since it asserts that:

> People who are climate science literate know that climate science can inform our decisions that improve quality of life. They have a basic understanding of the climate system, including the natural and human-caused factors that affect it. Climate science literate individuals understand how climate observations and records as well as computer modelling contribute to scientific knowledge about climate. They are aware of the fundamental relationship between climate and human life and the many ways in which climate has always played a role in human health. They are capable of assessing the validity of scientific arguments about climate and to use that information to support their decisions. (Dupigny-Giroux, 2010, p.1204)

These reflections about the term climate literacy are not new in the search for a conceptual and functional clarity around the notion of scientific literacy and its derivatives. Similar difficulties appear in the study by Sara Pe'er, Daphne Goldman & Bela Yavetz (2007). These researchers tried to define the concept of environmental literacy by identifying three fundamental components that are inter-related: *environmental knowledge*, which includes the understanding of basic ecological principles in order to understand how human beings influence ecosystems; *the inter-relation between social and natural systems* alongside the environmental problems that emerge from this relationship; and, *strategies for environmental action* that include the ability to identify and critically evaluate possible solutions. This proposal also starts from a three-dimensional vision that integrates conceptual, attitudinal —and, indirectly, ethical— and procedural knowledge, or behavioral. Although this suggestion ignores the emotional components, dynamics of social representation and those linked to cultural cognition, they might be considered implicit in the attitudinal dimension.

Beyond the conceptual clarification, Dupigny-Giroux (2010) indicates in a more realistic way the need for climate literacy to be an objective of education throughout life and for all citizens. The author identifies six challenges to be faced in order to achieve scientific literacy development, some of which agree with the views of Busch & Román (2017) in reference to the complexity involved in the interpretation and understanding of scientific discourses:

– The first challenge lies in the difficulty of the language of climate science since the specific terminology of this field of knowledge makes their understanding more difficult. This is a barrier aggravated by using some metaphors that can give rise to misconceptions, as for example the widespread image of a hole in the ozone layer through where it enters the solar radiation, translating into a “huge misunderstanding” (Meira-Cartea, 2015) that relates the ozone layer depletion with direct causes or consequences of climate change.

– The second challenge is the difficulty of understanding the cause-effect processes of climate change and their possible solutions (Phillips et al., 2015).

– The third challenge is the need to adopt a perspective that includes a "curriculum" accessible to all people. The complex nature of climate science means that not all students of compulsory education and most of the population in general, can gain access to that knowledge comprehensibly (Meira-Cartea et al., 2013).

– The fourth challenge points to the need to pay attention to different learning styles. Considering this, the transposition of theoretical knowledge into everyday practices might be strengthened (Clary & Wandersee, 2014).

– The fifth challenge addresses improving the knowledge and practices of educators in order to avoid the reproduction and maintenance of misconceptions, as well as to prevent the proliferation of representations generated by negationist/climate change denial currents (Monroe et al., 2017).

– The sixth challenge emphasises the role of each person's life experience, highlighting how and where they get access to the information about climate change (Kahan et al., 2012).

In an attempt to unify a framework, in 2009, several governmental agencies in the United States (The National Oceanic and Atmospheric Administration and the National Science Foundation) and non-governmental agencies (The American Association for the Advancement of Science), together with scientists and educators, collaborated to create an educational protocol called *The Essential Principles of Climate Science Literacy* by United States Global Change Reseacrh Program (USGCRP, 2009), which proposes seven fundamental points that population should apprehend in order to make informed climate decisions:

1. The sun is the primary source of energy for Earth´s climate system.
2. Climate is regulated by complex interactions among components of the Earth system.
3. Life on Earth depends on, is shaped by, and affects climate.

4. Climate varies over space and time through both natural and man-made processes.
5. Our understanding of the climate system is improved through observations, theoretical studies, and modelling.
6. Human activities are impacting the climate system.
7. Climate change will have consequences for the Earth system and human lives. (USGCRP, 2009, pp. 10-16)

It is nonetheless surprising that the official Spanish version of this document translates the term literacy by *conocimiento* (knowledge) thus becoming: Climatic knowledge: The essential Principles of Climate Science. This translation, which identifies literacy with the transmission of knowledge, remains throughout the document and shows the complexity of defining the "literacy" construct in a unique way capable of transcending the reductionist approaches to the information deficit model. On the other hand, the document also uses the terminology "climate science literacy", assuming that it is a subset of scientific literacy.

Nevertheless, the document offers a main definition of climate literacy as "an understanding of your influence on climate and climate´s influence on you and society" (USGCRP, 2009, p.4), which is a suggestive conceptualization that is likely to provide an opportunity for a more complex approach of the educational practices for developing it beyond a simple transmission of specific knowledge. However, this concretization addresses to four aspects that specifies that a climatically literate person would be one who:

- Understands the essential principles of Earth´s climate system.
- Knows how to asses scientifically credible information about climate.
- Communicates about climate and climate change in a meaningful way, and
- Is able to make informed and responsible decisions with regard to actions that may affect climate. (USGCRP, 2009, p. 4)

These four essential competences allow us to connect with the previously used definition of literacy, understood as teaching someone to interpret and generate scientific discourses (Norris & Philips, 2003). This is a goal that, if achieved, is likely to facilitate, in theory, the development of these competences. Climate science is one of the most valuable resources for understanding the complex climate system, its rapid changes and the extent of their most likely consequences. It allows us to start from an empirical basis to construct the problem. But its mere transfer to the public "does not imply that climate literacy of the social group is going to cause the change of behaviors, habits and values in the everyday life of people" (González-Gaudiano & Meira, 2009, p.12).

In addition, climate literacy has another obstacle to facing the difficulty of the climate literacy definition, which would facilitate the proposal of pedagogical interventions in the different areas of social life in order to achieve a necessary transformation: it stands up to a global and abstract problem in which it is difficult to identify personal contribution among solutions, weakening the belief and the feeling of self-efficacy. This contrasts with the goal of environmental literacy, where one of its purposes is to "empower people with a belief in their ability to contribute to environmental solutions through personal behavior, either as an individual or part of a group” (Pe'er, Goldman, & Yavetz, 2007, p.47), a goal that might be achieved and visible in short or medium term through different interventions of care, protection or conservation of the environment.

On the other hand, there are researches (Hornsey, Harris, Bain, & Fielding, 2016; Kahan et al., 2012) that directly relate beliefs, ideologies and visions of the world, individualistic and hierarchical, with denialist behaviors. These studies are not intended to criticize the need or not to climate-literate citizens, but they provide extra information to understand the extent of impact that literacy might have on understanding the problem and their risk perception.

At this point, we presented the outcomes of a study carried out at the University of Santiago de Compostela (USC). The aim was to explore the current level of students regarding climate literacy by comparing, on the one hand, students whose courses are in the field of the Natural Sciences and Engineering were compared with those students studying in the field of the Social Sciences and Humanities. And on the other hand, students who were beginning their studies with those who were finishing them. This is a first step in order to investigate and deal with the behavioral dimension that is required to face climate change.

COLLEGE STUDENTS´ CLIMATE LITERACY: A RESEARCH INTO UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

The goals of this investigation were:

- To assess the current state of college students´ climate literacy in the USC, which will allow:

- To understand how the educational system influences the climate literacy levels of Secondary Education students, and finally

- To gain insight into how the university influences college students´ climate literacy.

PROCEDURE AND MEASUREMENT

In order to explore students´ understanding of climate change (CC), we have surveyed college students with a three sections questionnaire:

a) The first section is related to personal information: gender, age, university course and academic year.

b) The second section consists of 32 items designed to explore interactions between scientific culture and common culture. The questionnaire measures student's competence in identifying the scientific veracity or falsity of a series of statements, which are in fact either true or false. These statements are classified into four areas of knowledge related to the first two principles of climate literacy according to the USGCRP (2009):

Area 1. Physical processes related to CC (8 statements).

Area 2. Consequences of CC (10 statements)

Area 3. Causes of CC (10 statements)

Area 4. Responses to CC (4 statements).

Items are close-ended questions and reproduce common sentences about climate change that could be found both in the literature of scientific dissemination and in the media. They do not appear ordered according to the related area of knowledge in order to avoid conditioning answers. Items that didn´t discriminate the answers adequately in a pilot test were suppressed.

The close-ended questions are based on a Likert scale of 4 elements to assess the degree of knowledge of the students. Each statement was followed by four boxes and students were asked to check the appropriate box: "Totally true" (TT), "Probably true", "Probably false" and "Totally false" (TF). This scale allows us to measure the scientific correctness of the answers on a scale from 1 to 4, 4 being the maximum value of agreement —correctness— between scientific culture and common culture. Statements correct answer are based on Intergovernmental Panel on Climate Change reports (2013, 2014). This value is related to the ability to read, interpret and assess scientific texts appropriately. In this section, there is not optioned to answer “doesn´t know/doesn´t answer” in order to avoid a non-reflective or evasive response.

c) The third section consists of 13 questions that are used to collect personal information and general beliefs of college students in relation to climate change. In this section there are different types of items: dichotomy questions (2), Likert scale of 4 elements (4) and Likert scale of 10 elements (7). Data from this section is not offered or analyzed in this paper.

Thus, the research sample was grouped both regarding the specific academic field and the university year coursed. During the application of the questionnaire, 300 of the students were in their first year of university and 19 in their second year —both data series were coded as one variable called “Beginning Studies” (NBS= 319)—, while 42 students were in their third year of university and 277 were in their fourth year of university —both series of data were coded as one variable called “Finishing Studies” (NFS=319)—. Regarding the degrees that the participants were studying, the sample is distributed as follows:

Table 1.
Sample by disciplines

Natural Sciences and Engineering	**Social Sciences and Humanities**
Biology (99)	Pedagogy (96)
Forest and Natural Environment Engineering (44)	Law (121)
Agricultural Engineering and Food (42)	Economics (105)
Chemical Engineering (61)	History (76)

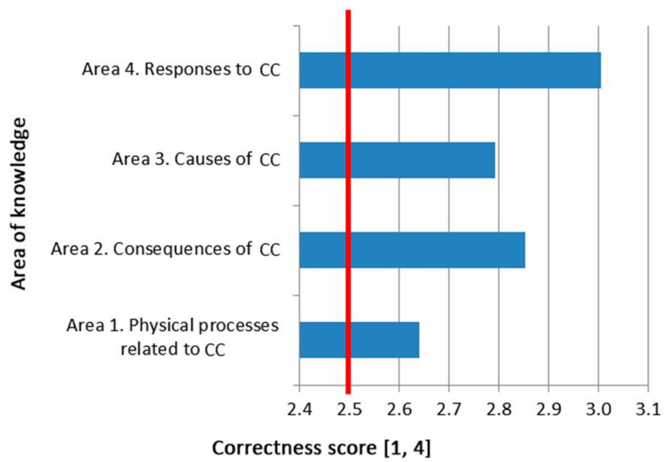
Note: NSE: Natural Sciences and Engineering; SSH: Social Sciences and Humanities. N_{NSE}=246; N_{SSH}=398 (6 lost cases)

GENERAL RESULTS

General results are represented in Figure 1 (2nd section of the questionnaire). We have defined three different levels of scientific correctness: Low-level = M<2.5; Medium-level = 2.5<M<3; and, High-level = M>3.

The average values per item obtained for the full sample are presented in tables 2, 3, 4 and 5. It should be noted that in all areas of knowledge an average score above 2.5 was obtained, which is the threshold that we define as low climate literacy level. This threshold was defined in this way since the statements in which the average score was less than 2.5, corresponded to a median (Me) which equals 2, which means that at least half of the participants replied incorrectly (see tables 2, 3, 4 and 5)

Figure 1. Average correctness score according to areas of knowledge (means). Red line indicates low-level scientific correctness



According to Figure 2 ―general averages per item― in more than 30% of items, college students presented a medium-low climate literacy level (2.5 >M>3), while in more than 60% of items, college students show a high climate literacy level (M>3). The distribution of the answers shows levels of scientific correctness with very separate maximum and minimum values [1.6-3.6].

Figure 2. Average of correctness score for 2nd section of the questionnaire (per item). Items are transcribed in table 2, 3, 4 and 5

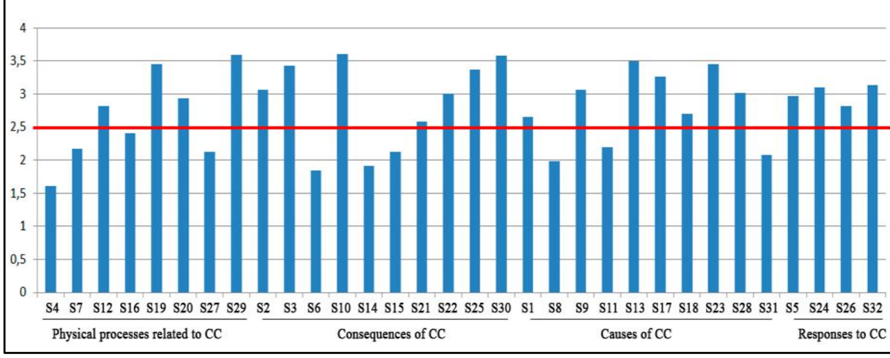


Table 2.

General outcomes of the area 1. Physical processes related to CC

Item/Statement	Mean	M_{NSE} (Me)	M_{SSH} (Me)	M_{BS} (Me)	M_{FS} (Me)
S4. The polar hole of the ozone layer causes the melting of the poles	1.60	1.56 (1)	1.65 (1)	1.58 (1)	1.63 (1)
S7. The acid rain is one of the causes of climate change.	2.20	2.32 (2)	2.08 (2)	2.15 (2)	2.25 (2)
S12. If it were not the greenhouse effect, there would be no life as we know it.	2.86	3.07 (3)	2.65 (3)	2.85 (3)	2.88 (3)
S16. Climate change is a consequence of the hole in the ozone layer.	2.42	2.48 (2)	2.37 (2)	2.48 (2)	2.37 (2)
S19. The greenhouse effect occurs when gases retain part of the radiation reflected by the Earth's surface.	3.48	3.57 (4)	3.39 (4)	3.51 (4)	3.45 (4)
S20. Sea level is increasing due to the expansion of water by the rise of temperature.	2.90	2.81 (3)	3.00 (3)	2.75 (3)	3.08 (3)
S27. The CO_2 causes the destruction of the ozone layer.	2.14	2.30 (2)	1.98 (2)	2.05 (2)	2.24 (2)
S29. According to Earth's climatic history, there have been oscillations between colder and warmer periods.	3.60	3.63 (4)	3.57 (4)	3.63 (4)	3.58 (4)

Note: M: mean; Me: median; NSE: Natural Sciences and Engineering; SSH: Social Sciences and Humanities; BS: Beginning Studies; FS: Finishing Studies.

Table 3.

General outcomes of the area 2. Consequences of CC

Item/Statement	Mean	M_{NSE} (Me)	M_{SSH} (Me)	M_{BS} (Me)	M_{FS} (Me)
S2. A warmer planet will expand the area of incidence of tropical diseases.	3.07	3.21 (3)	2.94 (3)	3.12 (3)	3.03 (3)
S3. The increased temperatures will favour the concurrence of extreme weather events (cyclones, hurricanes, floods, etc.).	3.41	3.44 (3)	3.38 (3)	3.37 (3)	3.45 (3)
S6. Skin cancers will increase as a result of climate change.	1.84	1.78 (2)	1.91 (2)	1.75 (2)	1.95 (2)
S10. All countries will suffer climate change.	3.60	3.65 (4)	3.56 (4)	3.62 (4)	3.59 (4)
S14. The greenhouse effect puts in risk life in the Earth.	1.89	2.00 (2)	1.79 (2)	1.91 (2)	1.89 (2)
S15. Climate change will increase the number of earthquakes and tsunamis.	2.16	2.22 (2)	2.11 (2)	2.23 (2)	2.10 (2)
S21. The climate change will decrease the rainfall in my country.	2.59	2.64 (3)	2.54 (3)	2.61 (3)	2.57 (3)
S22. The rising temperatures will affect all regions of the planet alike.	3.03	3.00 (3)	3.06 (3)	3.00 (3)	3.06 (3)
S25. Climate change will exacerbate problems of desertification in the Iberian Peninsula.	3.36	3.40 (3)	3.32 (3)	3.38 (3)	3.33 (3)
S30. Many islands and coastal areas will be submerged due to climate change.	3.6	3.60 (4)	3.58 (4)	3.57 (4)	3.61 (4)

Note: M: mean; Me: median; NSE: Natural Sciences and Engineering; SSH: Social Sciences and Humanities; BS: Beginning Studies; FS: Finishing Studies.

Table 4.
General outcomes of the area 3. Causes of CC

Item/Statement	Mean	M_{NSE} (Me)	M_{SSH} (Me)	M_{BS} (Me)	M_{FS} (Me)
S1. The greenhouse effect is a natural phenomenon.	2.66	2.96 (3)	2.36 (2)	2.68 (3)	2.64 (3)
S8. Most of greenhouse gases present in the atmosphere come from natural sources.	1.98	2.05 (2)	1.91 (2)	1.96 (2)	2.01 (2)
S9. The CO2 is the main gas responsible for climate change	3.06	3.14 (3)	2.98 (3)	3.05 (3)	3.07 (3)
S11. The increase in meat consumption contributes to climate change.	2.23	2.39 (2)	2.07 (2)	2.05 (2)	2.42 (2)
S13. Every time coal, oil or gas is used, we contribute to climate change.	3.55	3.63 (4)	3.48 (4)	3.58 (4)	3.52 (4)
S17. Climate change is caused by human activity.	3.29	3.30 (3)	3.29 (3)	3.27 (3)	3.33 (3)
S18. Climate change is the result of natural climatic variability.	2.71	2.63 (3)	2.79 (3)	2.69 (3)	2.73 (3)
S23. The CO2 is a natural component of the atmosphere.	3.49	3.66 (4)	3.33 (4)	3.52 (4)	3.48 (4)
S28. There is scientific consensus when considering human activity as the main cause of climate change.	3.01	3.01 (3)	3.02 (3)	3.04 (3)	3.00 (3)
S31. The greenhouse effect is caused by human activity.	2.07	2.24 (2)	1.91 (2)	2.07 (2)	2.09 (2)

Note: M: mean; Me: median; NSE: Natural Sciences and Engineering; SSH: Social Sciences and Humanities; BS: Beginning Studies; FS: Finishing Studies.

Table 5.
General outcomes of the area 4. Responses to CC

Item/Statement	*Mean*	*M_{NSE} (Me)*	*M_{SSH} (Me)*	*M_{BS} (Me)*	*M_{FS} (Me)*
S5. If we stop emitting greenhouse gases, we will not be affected by the climate change.	3.00	3.06 (34)	2.94 (3)	2.91 (3)	3.1 (3)
S24. If we stop emitting greenhouse gases, we will be less vulnerable to the climate change.	3.10	3.16 (3)	3.05 (3)	3.16 (3)	3.04 (3)
S26. The climate change would be reduced if we planted more trees.	2.86	2.99 (3)	2.74 (3)	2.89 (3)	2.84 (3)
S32. Replacing private transport by the public is one of the most effective measures to address the climate change	3.12	3.10 (3)	3.14 (3)	3.18 (3)	3.06 (3)

Note: M: mean; Me: median; NSE: Natural Sciences and Engineering; SSH: Social Sciences and Humanities; BS: Beginning Studies; FS: Finishing Studies.

In the first area of knowledge 50% of the answers show a medium-low climate literacy level (Table 2). These outcomes match with statements that mention physical-chemical phenomena —the occurrence of acid rain and the depletion of the ozone layer— which in fact share no causal relationship with climate change.

In area 2 (table 3) college students demonstrated a high climate literacy answering 60% of statements and a medium-low climate literacy level in 30% of them. Outcomes of medium-low levels correspond again with physical phenomena in which there are no relation with climate change —in this case such as the increase of tsunamis and earthquakes¬—. It is noteworthy the statement 6 that implicitly relates the hole in the ozone layer with skin cancers, as the misconception between concepts greenhouse effect and climate change.

Table 4 shows the results of area 3 of knowledge. In this area participants obtained high climate literacy levels in 50% of the statements compared to 30% in which these levels are medium-low. In this case it is interesting to examine four of the statements that are closely related and, which nevertheless, obtain disparate scores; S8 and S31, both offer low levels, and S9 and S23 which correspond with high levels. They are very similar statements in which different scientific concepts come into play: "gasses", "CO2", "atmosphere", "greenhouse effect", "human activity" and "natural sources". The statements refer to similar ideas and phenomena, but nevertheless answers are opposite. This behavior is an example of how social representations serve as an "automatic pilot" to interpret reality. Despite possessing and demonstrating knowledge about certain scientific topics —such as "the CO2 is the main gas responsible for climate change" (MS9 = 3.06) and which also "is a natural component of the atmosphere" (MS23 = 3.49)— social representations are automatically manifested with common culture overriding scientific culture when directly relating a natural phenomenon such as the greenhouse effect (MS8 = 1.98) with human activity (MS31 = 2.07).

Finally, Table 5 shows outcomes of area 4 (responses to climate change), which suggest that despite the existence of misconceptions and "profane folk theories" among these college students, they correctly recognize actions and behaviors which mitigate climate change, obtaining in all their answers medium-high and high climate literacy levels.

COLLEGE STUDENTS´ CLIMATE LITERACY: STUDENTS OF NATURAL SCIENCES AND ENGINEERING VS THAT OF STUDENTS OF SOCIAL SCIENCES AND HUMANITIES

This section describes the analysis of students´ answers regarding the broad discipline they are studying. The overall sample has been broken down into two subsamples as explained earlier. The aim is to explore the first hypothesis:

H1. College students of studies related to Natural Sciences and Engineering (NSE) have a higher climate literacy level than students of studies related to Social Sciences and Humanities (SSH).

A significantly higher result —identifying the veracity or falsehood of statements— of those students who are studying university degrees with contents related to climate science, would be expected.

Table 6 shows the general results by areas of knowledge and by university degree subsample. There were statistically significant differences in the distributions of responses (ANOVA) between areas of knowledge and of university degree fields.

Table 6.
Global results by areas and by sub-samples: Analysis of variance (ANOVA) was performed

Areas of knowledge	M_{NSE}	M_{SSH}	*Sig.*	*F*	*df*
A1. Physical processes related to CC	2.71	2.59	0.001	10.284	440
A2. Consequences of CC	2.89	2.83	0.002	10.125	447
A3. Causes of CC	2.89	2.73	0.000	38.282	448
A4. Responses of CC	3.07	2.96	0.009	6.901	475

Note: N=644; N_{NSE}=246; N_{SSH}=298; Mean in scale [1 to 4] where 4 is the maximum correctness. df = degrees of freedom. Significance level $\alpha<0.05$

These data suggest that the scientific knowledge necessary to identify the veracity or falsehood of statements does vary in relation to the modality of compulsory education which allow to access to the University, that could indicate that secondary school education (12 to16 years) could offer a standard education related to CC, and it is in sixth form (17 to 18 years) when students learn specific contents, in this case, about climate change. These outcomes also suggest that university studies which include contents of climate sciences get access to a more accurate scientific knowledge, but it does not imply to change some misconceptions that are strongly stablished into de core of the social representation

COLLEGE STUDENTS´ CLIMATE LITERACY: STUDENTS WHO ARE BEGINNING THEIR STUDIES VS STUDENTS WHO ARE FINISHING THEIR STUDIES.

This section presents the analyses corresponding to the two groups established as BS ―Beginning of University Studies―, which includes the students who are performing 1st and 2nd academic year and as FS ―Final of University Studies―, integrated by students of 3rd and 4th academic year. The aim is to explore the second hypothesis:

H2. Students who are finishing their university degree studies have higher levels of scientific correctness by pointing out the veracity or the falsehood of scientific statements that those students who are starting their respective university studies.

According to this, significantly higher results of climate literacy are expected in the answers of those students who are completing their studies due to the contact with the scientific knowledge they have had access throughout their University experience. However, we find that there is little difference between subsamples (table 7), where FS group obtained a higher score in areas 1 and 3 while in area 4, BS group gets higher score.

Table 7.

Global scores by academic course BS & FS. analysis of variance (ANOVA) was performed

Areas of knowledge	M_{BS}	M_{FS}	*Sig.*	*F*	*df*
A1. Physical processes related to CC	2.62	2.69	0.087	2.939	440
A2. Consequences of CC	2.85	2.85	0.855	0.034	447
A3. Causes of CC	2.79	2.83	0.188	1.738	448
A4. Responses of CC	3.03	3.00	0.429	0,626	475

Note: N=644; N_{BS}=319; N_{FS}=319; N_{lost}=6. Mean in scale [1 to 4] where 4 is the maximum correctness. df = degrees of freedom. Significance level $\alpha<0.05$

In this case, there were not statistically significant differences in the distributions of responses (ANOVA). In view of these results, the second hypothesis cannot be accepted, considering that both sets of students presented a similar level of scientific correctness.

These findings reinforce the idea that knowledge with which college students elaborate their representation of CC comes to a greater extent from their common culture than from their academic experience. New knowledge is captured and re-signified outside the university, either through personal experience, interaction with the media and/or with other people, or superficial contact with Climate Sciences in their passage through teaching Compulsory Education.

DISCUSSION

Outcomes of this study cannot completely corroborate assertions that the positivist approach focused on mere transmission of scientific content are not effective as a solution to CC (González-Gaudiano, 2012). We should analyze the 3er section of our questionnaire to verify if risk perception and other attitudinal behaviors for mitigation and adaptation to CC is correlated with climate literacy levels —we can anticipate there is not such a statistical correlation—. In any case, the positivist approach does not seem to help to detect and understand causes and consequences of the problem considering that misconceptions happen repeatedly (Table 2, 3, 4 and 5) despite educational efforts to minimize them (Dupigny-Giroux, 2010; Giordan, 1989). Pervasiveness of these misconceptions has been widely studied in various studies in different countries and with different population (Cordero, Todd & Abellera, 2008; Fortner, 2001; Leiserowitz, 2005, 2006; Leiserowitz, Smith & Marlon, 2010; Meira, 2015; Meira et al., 2013; Shepardson, Choi, Niyogi, & Charusombat, 2011; Wachholz, Artz & Cheme, 2014). Thus, our research notes its permanence in the imaginary of common culture of college students of Santiago de Compostela University, clearly interfering in the representation of climate change as a scientific object.

Our outcomes also suggest that students do not get knowledge, information and/or relevant activities that lead to a significant improvement in their levels of climate literacy throughout their University Education. It seems that college students do not transform their representations of climate change towards others more coherent with the available scientific knowledge, reinforcing the idea that among them also common culture offers more elements to build the social representation of climate change than scientific culture. On the other hand, as we can see in table 5 —which shows results of area 4 about responses to CC— results suggest that despite the existence of misconceptions and "folk" theories among college students, they recognize some actions and behaviours for mitigation of global warming. This reinforces the idea of Stevenson, Nicholls & Whitehouse (2017) as to the need to face the challenge of an incomplete knowledge without weakening the need to reflect and act in a transition to a truly sustainable future. What is more, outcomes suggest that much of this specific knowledge is acquired by the sum of personal experience through the processes of socialization and social interaction that build the common culture out of the educational system, and through the formative experience in Secondary Education and Sixth Form.

CONCLUSIONS

However, the theory of social representations offers a useful theoretical framework from which to guide research regarding climate literacy. The fact that social representations are built through social interaction and vary with the passage of time suggests the need to increase studies on this issue in different social groups. The specificity that social representations present —depending on the social, historical and cultural contexts, unique in every moment and in each society in particular— urges that this dimension should be considered in decision making at the political and environmental level in all the governments of the world.

One of the most important obstacles to the social representation of climate change is the uncertainty that is generated around the phenomenon. Anchoring and objectification are processes that take place in building a social representation in which level of uncertainty presented by the new "object" ―climate change, in this case― affects its assimilation in the cognitive system (Duveen & Lloyd, 2003). It also affects during communication, expression or action regarding this object. As González-Gaudiano & Meira indicate, "the economy of efforts that governs everyday life finds in uncertainty an excuse to postpone decision-making" (2009, p.18).

In this respect Kahan et al. (2012) indicate that recent psychological studies identified two systems for information processing, in this case regarding risk perception of climate change: one that encompasses rapid visceral judgments manifested in various forms of decision-making for troubleshooting and immediate action; and a second system that requires conscious reflection and planning. Their research suggests that public personalities and public managers mainly use the first system to carry out their communicative interventions, which require less effort at the time of decision-making. This links perfectly with the use that social representations offer as cognitive shortcuts to interpret and act.

Our results also address that the university, as the main generating and disseminating institution of knowledge, does not seem to be a significant influence on the way the climate crisis is being understood and represented by its students. The work done so far by SEPA-Interea research group and Resclima project should serve as an example in order to offer educational proposals that materialize in an "Education for Climate Change" throughout life, an education for all citizens aimed at facilitating mitigation and adaptation to climate change. To understand how the phenomenon is being integrated into college student imaginary is a step towards this end. But due to the urgency of the situation, it is necessary for agency, where the programmatic and management decisions are taken, to carry out actions and interventions at all structural levels. Actions that influence both curricular programs and daily life in university campuses so that these could serve as an example to the whole society and offer a path based on the knowledge which allows us to face the uncertain future of a deeply altered climate.

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NOTES

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