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Characterising educational research on climate change in the climate emergency era (2017–2024)

Caracterización de la investigación educativa sobre cambio climático en la era de la emergencia climática (2017-2024)

Marta SEGADE-VÁZQUEZ. Biotechnology Graduate, Universidad de Santiago de Compostela *(marta.segade@rai.usc.es)*.

Antonio GARCÍA-VINUESA, PhD. Assistant Professor, Universidad de Santiago de Compostela *(a.garcia.vinuesa@usc.es)*.

Ana RODRÍGUEZ-GROBA, PhD. Assistant Professor, Universidad de Santiago de Compostela *(ana.groba@usc.es)*.

Júlio J. CONDE, PhD. Postdoctoral Researcher, Universidad de Santiago de Compostela *(julio.conde@usc.es)*.

Abstract:

Recent national and international statements have put the state of the climate in a new paradigm, that of a climate emergency demanding urgent action. In this context, contributions from educational research are essential to inform educational policies and practices. Previous studies identified a marked increase in scientific literature on this topic over the period from 2008 to 2017. Seven years on, with more than 2300 climate emergency declarations having been issued by jurisdictions representing over one billion people, it seems timely to update the characterisation of this field. This documentary study aims to examine educational research on secondary education students' understanding of climate change during the period from 2017 to 2024. The study builds on an earlier review (1993–2017) and analyses current trends in the field. Following the PRISMA-ScR guidelines, an action protocol was developed, eligibility criteria were defined, and records were retrieved from the Web of Science and Scopus databases. The CADIMA online application, designed for systematic evidence synthesis, was employed to streamline the process. This resulted in 55 articles being identified. The analyses found that the increase in publication volume noted up to 2017 has continued, with research expanding to new geographic regions and including a broader range of participants. The findings also indicate new research directions, including emotional dimensions, personal contexts, and methodological approaches such as social representation theory. This study offers an updated overview of the field, intended to support education professionals in both pedagogical practice and research.

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Keywords: students, review, secondary education, high school, environmental education, climate emergency, climate education, CADIMA.

Resumen:

Las últimas declaraciones nacionales e internacionales sitúan la realidad climática en una nueva dimensión, la de una emergencia climática ante la que es imperativo actuar. En este escenario, las contribuciones de la investigación educativa son determinantes en la orientación de políticas y prácticas educativas. La literatura científica al respecto sufrió un incremento en su producción en el período 2008-2017. Siete años después y con más 2300 declaraciones de emergencia climática promulgadas por jurisdicciones que representan a más de mil millones de personas, parece oportuno actualizar la caracterización de este ámbito. Mediante un estudio documental, se pretende caracterizar el campo de la investigación educativa en relación con la comprensión del cambio climático por estudiantes de educación secundaria en el periodo 2017-2024. Con ello, se busca actualizar una revisión previamente realizada (1993-2017) y analizar las tendencias dentro del campo de estudio. Se siguió la declaración PRISMA-ScR, se planificó el protocolo de actuación, se establecieron los criterios de elegibilidad y se utilizaron las bases de datos de Web of Science y Scopus para la búsqueda de registros. En el proceso, se utilizó la aplicación online CADIMA, diseñada para sistematizar síntesis de evidencias. Como resultado, se identificaron 55 artículos. Los análisis desvelan que el incremento en la producción identificado hasta 2017 se mantiene en la actualidad, con una ampliación de horizontes geográficos y un mayor rango de participantes. Por otro lado, sugieren nuevas líneas de investigación tanto en lo que se refiere a tópicos e interés (dimensión emocional y contextos personales) como a propuestas metodológicas (teoría de las representaciones sociales). Este trabajo presenta una panorámica del campo de estudio con la pretensión de que sea de utilidad a los y las profesionales de la educación tanto en su praxis pedagógica como investigadora.

Palabras clave: estudiantes, revisión, educación secundaria, instituto, educación ambiental, emergencia climática, educación climática, CADIMA.

1. Introduction

Anthropogenic climate change (CC), defined as long-term change in the Earth's meteorological dynamic owing to human activities (IPCC, 2023), is undoubtedly one of the most important challenges of the 21st century (Debernardi et al., 2024). Because of its unprecedented impact on all aspects of life in society, social and political bodies (both nationally and internationally) have spoken about this phenomenon as an *emergency* and, since 2017, many groups and governments have called for and issued climate emergency declarations (Wilkinson & Clement, 2021). So far, 2,357 declarations have been made by jurisdictions representing more than a billion people (CEDAMIA, 2024). Similarly, various United Nations bodies have stressed the urgency of providing a global and local response that makes it possible to construct an environmental scenario that is as favourable as possible (United Nations, 2015a). Specifically, a need has been identified to educate new generations (who are the ones who will inherit this future) in how to lead and participate in the climate struggle.

In this emergency situation, education is a potential catalyst for citizen action (Ladrera & Robredo, 2022). According to the United Nations (2015b), teaching is and will remain crucial to promote awareness raising and the human capacity to mitigate and adapt to CC. In this regard, intergovernmental discourse insists firmly on the urgent need to integrate the climate

emergency into curricula, offering children and adolescents socioeducational spaces where they can access knowledge and develop the skills and attitudes needed to give active support (individually and collectively) to the necessary and urgent mitigation and adaptation strategies and policies. In this sense, González-Gaudiano et al. (2020) propose an emergency curriculum that, among other things, addresses the way the topic is addressed from individual disciplines, which limits the level of discussion, participation, reasoning, and reflection that is essential to address complex and controversial social and political questions. They call for a climate-emergency curriculum that considers and values contributions from other disciplines within the social sciences, which through their own methodologies and content make it possible to promote in depth the climate commitment from critical and ethical positions. A curriculum that cannot hide or delay the urgency of a transition towards a decarbonised and fair society while at the same time needing to project a "hope based on more constructive ways of coping with this threat" (Ojala, 2012, p. 636).

To do so, it is crucial to provide the different stakeholders from the educational community with well-founded resources to direct and facilitate the paradigm change on the climate topic; in other words, pedagogical research must prioritise the climate emergency as one of its key pillars. As one of the various educational elements or aspects to take into account, it is opportune to explore how students perceive, construct, and apply knowledge of CC. Furthermore, to facilitate access to the information generated and guide future research, this field of study should be characterised.

Therefore, the present work starts from the results of the review by García-Vinuesa and Meira-Cartea (2019) in which they offered a first inventory and characterisation of educational research into secondary education students' comprehension of CC in the 1993–2017 period. Seven years later, there is a need to update this review as no more recent ones have been found since its publication that offer an overview of the evolution of the field up to the present day. Consequently, this documentary study sets out to complement the results obtained in this earlier review and, using the systematic scoping review method (Codina, 2021; Gutierrez-Bucheli et al., 2022; Tricco et al., 2018), to offer a renewed perspective on the evolution of pedagogical research relating to the subject of the climate for the 2017–2024 period.

The following specific objectives are proposed:

1. To identify high-impact literature on secondary education students' comprehension of CC, that is to say, adolescents aged between 12 and 18 years.
2. To update the characterisation of the field of educational research focussed on adolescent students' comprehension of CC.

2. Methodology

A documentary methodological design was used to explore the scientific evidence regarding secondary education students' comprehension of CC. In order to offer a rigorous, traceable and transparent overview of the topic, the systematic scoping review method was used to do this (Gutierrez-Bucheli et al., 2022; Tricco et al., 2018).

Systematic scoping reviews are used in studies that synthesise evidence to explore the situation of a specific academic-scientific field in a wide-ranging and systematic way (Codina, 2021). This type of study pursues a variety of objectives, such as reviewing the extent, variety, and characteristics of the available evidence on a specific topic of study; assessing the utility of undertaking a more in-depth exploration of the topic; synthesising the methods and results identified in the area of knowledge examined; updating and complementing previous reviews; and identifying new research opportunities (Codina, 2021; Tricco et al., 2018).

This study follows the PRISMA-ScR declaration [the supplementary material includes the checklist that the authors of the declaration propose (Tricco et al., 2018)]. Codina (2021)

recognises the suitability of this technique for synthesising evidence in the field of educational research. It is especially recommended for the field of environmental education (Gutierrez-Bucheli et al., 2022). As a support tool for completing the process, the CADIMA online application was used. Its features guide and facilitate the realisation of collaborative and transparent systematic reviews (Kohl et al., 2018).

Accordingly, and as PRISMA-ScR recommends, the protocol that guided the review process was planned and registered (Segade-Vázquez et al., 2024) and its implementation is described below.

2.1. Eligibility criteria

To guide the type of question and establish the eligibility criteria, the PCC (population, concept, and context) framework was used. This is recommended for scoping systematic reviews in the field of education (Gutierrez-Bucheli et al., 2022; Zawacki-Richter et al., 2020). In line with this, the population was defined as *students*, the concept as *climate change*, and the context as *secondary education*. In addition, three other criteria were used to match the search to that done by García-Vinuesa and Meira-Cartea (2019): a time filter for the 2017-2024 period; another for publication type (only published articles; books, book chapters and grey literature were excluded); and, finally, a linguistic filter (only texts written in Spanish, Galician, English, and Portuguese).

To define the eligibility criteria objectively and adequately and avoid different interpretations by the reviewers, an internal consistency test was done using the kappa index calculation offered by CADIMA. A random sample was taken of 20 records that were assessed in parallel by two reviewers, giving a kappa index value of 0.649, which is considered to be good. The exact definition of the eligibility criteria can be consulted in Table 1 in the supplementary material.

2.2. Procedure for searching for and selecting records

The search was done from the network of the Universidade de Santiago de Compostela through its subscription to the Spanish Foundation for Science and Technology. The consultations were done on 24 April 2024 in the Scopus and Web of Science (WoS) databases, which are well-known for their rigour, their scope, and the notable scientific reach and of their indexed collections (Codina, 2021). To construct the search query, the concepts used by García-Vinuesa and Meira-Cartea (2019) were taken into account (*student, climate change, global warming, secondary, middle school*, and *high school*), combining them in the title, abstract, and keywords fields. The following search algorithm was used: (TITLE-ABS-KEY (student*) AND TITLE-ABS-KEY (“climate change” OR “global warming”) AND TITLE-ABS-KEY (“secondary” OR “middle school*” OR “high school*”)).

The searches of the two databases were done and the records obtained were entered into CADIMA where they were combined, and duplicates were eliminated automatically and manually. Once the initial sample had been obtained, the eligibility criteria were applied in two phases: one, by reading the titles and abstracts, and another by reading in-depth the full texts that passed phase one. The selection process was done by two reviewers in parallel.

2.3. Limitations

Despite the planned systematisation for carrying out this scoping review, no review process is without limitations. Therefore, to interpret the results that emerge, it is necessary to consider such constraints inherent to these processes. In particular, the following limitations should be noted in this review: a linguistic bias owing to the language competences of its authors, with only texts written in Spanish, English, Galician, and Portuguese being accepted. In addition, it should be noted that the selected databases

mainly index articles in English, although they increasingly include journals that publish in other languages. In relation to this, 25 records from WoS and Scopus were excluded from the analysis as they were written in other languages. Another typical limitation results from the restricted access to some articles. In our case, the full text of three studies could not be accessed and so they could not be assessed.

Finally, it is also worth recalling that, despite using a sufficiently broad search string, some studies might not have been identified owing to the wording of the abstract or the authors' choice of title and keywords. This happened with three studies of interest, which were incorporated once the final selection of records had been reviewed (Figure 1).

3. Results

Next, the results obtained, which complement the findings of the review by García-Vinuesa and Meira-Cartea (2019) are presented, offering an up-to-date characterisation of the field of research into education, CC, and secondary education students. Figure 1 is a flow chart illustrating the search and selection process in which 55 studies from the 2017-2024 period were identified. Before continuing, the reader should be aware that although the study presented has prioritised an exhaustive search, the limitations described above (type of publication, language, sources consulted, etc.) mean these results cannot be generalised nor can defining patterns be established in scientific literature on the topic. However, the resulting inventory of studies does provide an overview of this field of research, identifying the principal authors, reference institutions, and new thematic and theoretical lines in educational research regarding the climate emergency and secondary education students.

FIGURE 1. Flow chart of the exploratory systematic review process.

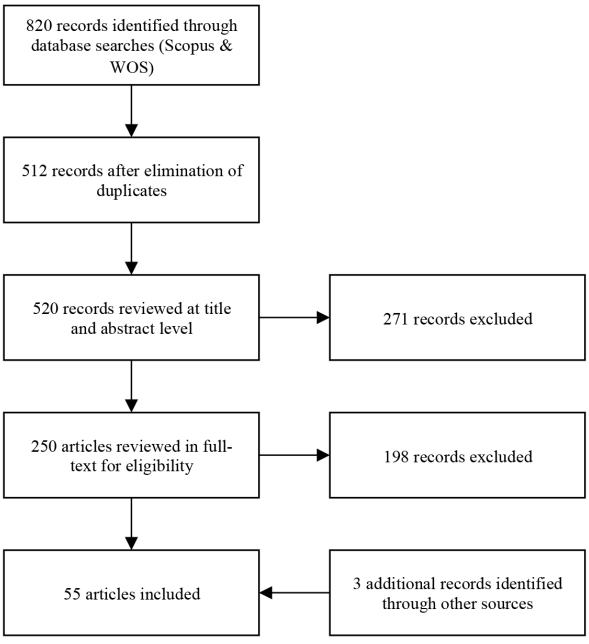


Table 1 presents the data extracted that enable a first approximation to the characterisation of the field of study in the period investigated.

TABLA 1. Datos descriptivos que caracterizan los estudios identificados en la revisión sistemática exploratoria

Authors	Year	Universities**	Country	*n*	Age	Origin	Design
García-Vinuesa, A., Carvalho, S., & Meira-Cartea, P. Á.	2024	Universidade de Santiago de Compostela	Spain	141	15-20	Portugal	MM
Ndetei, M., Wasserman, D., Mutiso, V., Shanley, J., Musyimi, C., Nyamai, P., Munyua, T., Swahn, S., Weisz, J., Osborn, T., Bhui, K., Johnson, N., Pihkala, P., Memiah, P., Gilbert, S., Javed, A., & Sourander, A.	2024	University (U) of Nairobi, Harvard U., U. of Oxford, U. of Basel, U. of Helsinki, U. of Maryland, U. of Turku**	Kenya, Sweden, USA, United Kingdom, Switzerland, Finland	2652	14-18	Kenya	QT
Cebrian, G., Moraleda, A., Olano, J., Boqué, A., & Prieto, J.	2024	U. Rovira i Virgili, U. Camilo José Cela, U. de Málaga	Spain	372	14-18	Spain	QT
De Rivas, R., Vilches, A., & Mayoral, O.	2024	Universitat de València	Spain	944	15-17	Spain	MM
Morote, A., & Hernández, M.	2024	Universitat de València, Universidad de Alicante	Spain	1328	12-18	Spain	MM
Ágoston, C., Balázs, B., Mónus, F., & Varga, A.	2024	ELTE Eötvös Loránd University, University of Debrecen	Hungary	112	16-18	Hungary	QT
Morote, A.	2023	Universitat de València	Spain	575	12-18	Spain	MM
Kirbiš, A.	2023	University of Maribor	Slovenia	1508	12-34	Slovenia	QT
Jiménez-García, M., Pérez-Peña, M.C., & López-Sánchez, J.A.	2023	Universidad de Cádiz	Spain	565	12-24	Spain	QT
Tolppanen, S., Kang, J., & Tirri, K.	2023	University of Eastern Finland, University of Helsinki	Finland	1703	12-15	Finland	QT

Authors	Year	Universities**	Country	*n*	Age	Origin	Design
Antronico, L., Coscarelli, R., Gariano, L., & Salvati, P.	2023	Italian National Research Council	Italy	420	13-20	Italy	QT
De Pascale, F.	2023	University of Palermo	Italy	≈110	16-18	Italy	QL
Goel, A., Iyer-Raniga, U., Jain, S., Addya, A., Srivastava, A., Pandey, R., & Rathi, S.	2023	Indian Institute of Technology, RMIT University**	India, Australia, France	693	12-19	India	QT
Sánchez-Almodóvar, E., Gómez-Trigueros, I., & Olcina-Cantos, J.	2022	Universidad de Alicante	Spain	784	13-16	Spain	QT
Bishoge, O., Ajayi, D., Mfinanga, S., & Aremu, A.	2022	Pan African University Life and Earth Sciences Institute, University of Ibadan**	Nigeria, Tanzania	685	12-23	Tanzania	QT
Sarrasin, O., von Roten, F., & Butera, F.	2022	University of Lausanne	Switzerland	639	14-22	Switzerland	QT
García-Vinuesa, A., Meira-Cartea, P. Á., Caride Gómez, J. A., & Bachiorri, A.	2022	U. de Santiago de Compostela, U. degli Studi di Parma	Spain, Italy	398/ 209	15-17	Spain, Italy	MM
Morote, A., & Hernández, M.	2022	Universitata de València, Universidad de Alicante	Spain	575	12-18	Spain	MM
Deisenrieder, V., Müller, S., Knoflach, B., Oberrauch, A., Geitner, C., Stötter, J., & Keller, L.	2022	Leopold-Franzens U., Pedagogical University Tyrol	Austria	≈170/ ≈251	13-15	Germany, Austria	QL
Calixto-Flores, R.	2022	Universidad Pedagógica Nacional Ciudad de México	Mexico	45	16-20	Mexico	QL
Ladrera, R., & Robredo, B.	2022	Univerdidad de La Rioja	Spain	219	14-16	Spain	MM

Authors	Year	Universities**	Country	*n*	Age	Origin	Design
Piscitelli, A., & D'Uggento, A.M.	2022	U. of Naples Federico II, U. of Bari Aldo Moro	Italy	1975	13-21	Italy	QT
Bishoge, O., Aremu, A., Ajayi, D., & Mfinaga, S.	2022	Pan African University, University of Ibadan**	Nigeria, Tanzania	685	14-20	Tanzania	QT
Moser, S., y Sebauer, S.	2022	University of Bern**	Switzerland, Austria	1129	16-20	Austria	QT
Winter, V., Kranz, J., & Möller, A.	2022	U. of Vienna, Research Institute of Forest Ecology**	Germany, Austria	80	15.9*	Austria	QL
Sigit, D., Azrai, E., Suryanda, A., Ichsan, I., Cahapay, M., Rahman, M., Portal, P., & Susanti, R.	2022	Universitas Negeri Jakarta, U. Mohammad Husni Thamrin, Mindanao State U., U. of Dhaka, U. of Campinas**	Bangladesh, Brazil, Philippines, Indonesia	366	-	Indonesia	QT
Jurek, M., Frajer, J., Fiedor, D., Brhelová, J., Hercik, J., Jáč, M., & Lehnert, M.	2022	Palacký University	Czechia	462	14-19	Czechia	QT
Kutywayo, A., Chersich, M., Naidoo, N., Scorgie, F., Bottoman, L., & Mullick, S.	2022	University of the Witwatersrand	South Africa	924	15.8*	South Africa	QT
Ganatsa, M., Tsakaldimi, M., & Ganatsas, P.	2021	Aristotle University	Greece	600	12-15	Greece	QT
Feucht, F., Michaelson, K., Hany, S., Maziarz, L., & Ziegler, N.	2021	U. of Toledo, Bowling Green University**	USA	≈700	16-19	USA	QL
Calculli, C., D'Uggento, A., Labarile, A., & Ribecco, N.	2021	University of Bari Aldo Moro	Italy	≈920	13-17	Italy	MM
Canaza-Choque, F.A., Escobar-Mamani, F., & Huanca-Arohuanca, J.W.	2021	U. Católica de Santa María, U. Nacional del Altiplano, Universidad Nacional de San Agustín de Arequipa	Peru	102	16-18	Peru	CL

Authors	Year	Universities**	Country	*n*	Age	Origin	Design
Haugestad, C., Skauge, A., Kunst, R., & Power, S.	2021	University of Oslo, University of Copenhagen	Denmark, Norway	362	16-22	Norway	MM
Bello-Benavides, L., Cruz, G., Meira-Cartea, P., & González-Gaudiano, É.	2021	Universidad Veracruzana, U. de Santiago de Compostela	Spain, Mexico	858	15-17	Mexico	CT
Zeeshan, M., Sha, L., Tomlinson, K., Azeez, P.	2021	Bharathidasan University	China, India	717	12-18	India	CT
Khan, N., Karpudewan, M., & Annamalai, N.	2021	Universiti Sains Malaysia	Malaysia	211	14-15	Malaysia	CT
García-Vinuesa, A., Carvalho, S., Meira-Cartea, P., Á., & Azeiteiro, U.	2021	Universidade de Santiago de Compostela, U. de Aveiro	Spain, Portugal	219	16-17	Portugal	CT
Ratinen, I.	2021	University of Lapland	Finlandia	665	12-15	Finland	CT
Calixto-Flores, R.	2020	Universidad Pedagógica Nacional Ciudad de México	Mexico	67	15-21	Mexico	CL
Ratinen, I., & Uusiautti, S.	2020	University of Lapland	Finlandia	665	12-15	Finland	CT
Wu, J., & Otsuka, Y.	2020	Tokio City University**	China, Japan	657	16-17	China	CT
Montero-Pau, Álvaro, N., Gavidia, V., & Mayoral, O.	2020	Universitat de València	Spain	407	16.1*	Spain	CT
García-Vinuesa, A., Bello-Benavides, L., & Iglesias, L.	2020	Universidade de Santiago Compostela y Universidad Veracruzana	Spain, Mexico	298 /300	14-18	Spain, Mexico	CT
García-Vinuesa, A., Mucova, S., Azeiteiro, U., Meira-Cartea, P. Á., & Pereira, M.	2020	Universidad de Santiago de Compostela, Lúrio University, Universidade de Aveiro	Spain, Portugal, Mozambique	256	16-18	Mozambique	CT

Authors	Year	Universities**	Country	*n*	Age	Origin	Design
Lehnert, M., Fiedor, D., Frajer, J., Hercik, J., & Jurek, M.	2019	Palacký University	Czechia	462	14-19	Czechia	CT
Jarrett, L., & Takacs, G.	2019	University of Wollongong	Australia	229	13-16	Australia	MM
Ezze, E.	2019	University of Nigeria	Nigeria	312	-	Nigeria	CT
Majer, J., Slapničar, M., & Devetak., I.	2019	University of Maribor, Univerity of Ljubljana	Slovenia	1012	14-15	Slovenia	CT
Busch, K., Ardoin, N., Gruehn, D., & Steveson, K.	2019	North Carolina State University, Stanford University	USA	453	14-18	USA	CT
Pinheiro, J., Cavlacanti, G., & Barros, H.	2018	U. Federal do Rio Grande do Norte, U. Potiguar	Brasil	36	15.5*	Brasil	MM
Brandmo, C., & Bråten, I.	2018	University of Oslo, University of Copenhagen	Norway	281	17.1*	Norway	CT
Sanchis, R., Solaz-Portolés, J., & Sanjosé, V.	2018	Universitat de València	Spain	151	12-15	Spain	CT
Gasparetto, M., Teixeira, D., Roazzi, A., & Campello, B.	2018	Federal University of Pernambuco**	Brasil	200	16.7*	Brasil	CT
Valdez, R., Peterson, M.N., & Stevenson, K.	2017	Department of Forestry and Environmental Resources, Department of Parks, Recreation & Tourism Management	USA	1158	12-14	USA	CT
Li, C., & Monroe, M.	2017	University of Missouri, University of Florida	USA	728	14-18	USA	CT

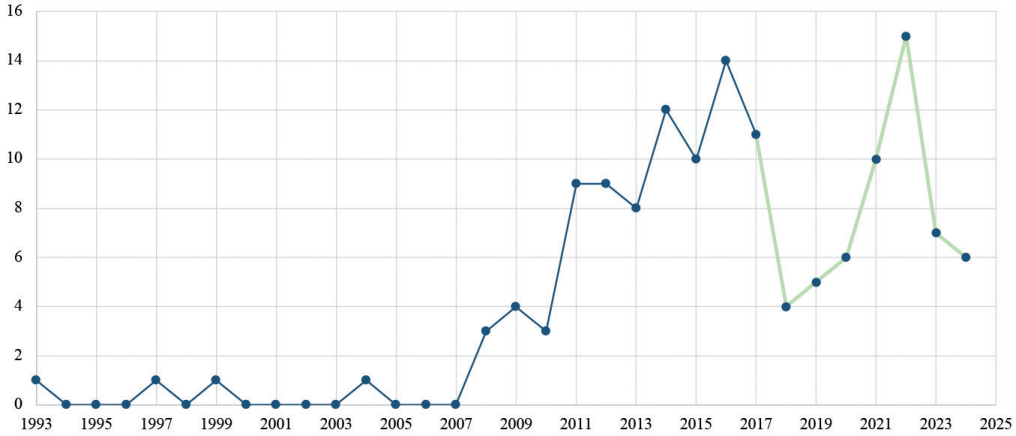
*Mean age. **Only the universities that led the research are listed, although in some cases research centres, high schools, and other institutions participated.

Note: the list of references of the identified studies can be consulted in the supplementary material. U = university; QT = quantitative; QL = qualitative; MM = mixed methods; n = sample.

3.1. Publication trends

In the 1993-2017 period, García-Vinuesa and Meira-Cartea (2019) identified an upwards trend in the publication of research centred on secondary education students' comprehension of CC. As the result for the 2017–2024 period show (Figure 2), this pattern, which started in 2008, has continued over time. However, the number of publications fell slightly in the years 2018 and 2019. Despite this, four and five studies were published in these two years, two and three more than in the first year of the previously identified increase in publications. It should be noted that the data for 2024 only cover January, February, March, and April, and so it is plausible that new studies will be published over the course of the year.

FIGURE 2. Publication trends by year.



3.1.1. Principal journals

Table 2 shows the journals that have published articles on the topic of this review. In comparison with the results of the previous review, the journal *Sustainability* emerges as the journal with the most publications, 9 in total, while in the previous period it only boasted one publication. This result is also notable because this journal is not from the field of education, but instead WoS catalogues it in the areas of environmental sciences, environmental studies, and sustainable science and technology. The following 6 journals (with 4, 3, and 2 publications) do belong to the areas of education, whether they are journals dedicated to environmental education or science teaching, while journals from other areas of knowledge are also found among the remaining journals with just 1 publication each (29 in total). So, over the last 7 years, 50.9% of articles on the topic were published in journals from the area of education and social sciences while 49.1% were in journals from other areas of study such as psychology or environmental sciences and sustainability.

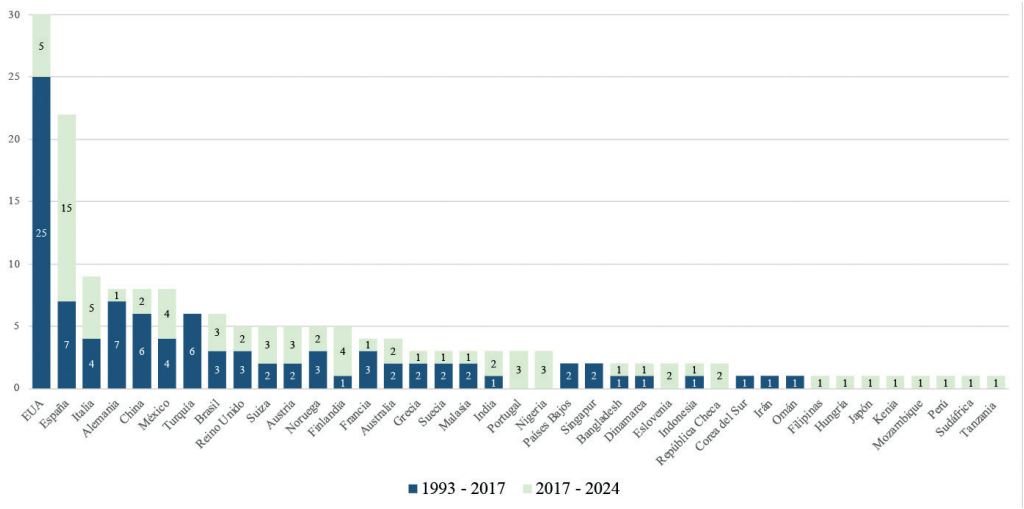
3.1.2. Overview and international scope

The addition of 12 new countries to the 27 in the previous review has been identified. Figure 3 shows that the United States is still the country that leads the most research, although its collaborations have reduced notably, going from 25 studies to five in the 2017-2024 period. In contrast, in the last 7 years, the largest number of research works (15 studies) have come from Spanish institutions, putting them at the forefront of educational research on CC. The total number of studies in Figure 3 does not match the results of the review as many of them are the product of interuniversity collaborations (Table 1).

TABLE 2. Journals and number of publications.

Journal	Articles
Sustainability	9
Environmental Education Research (EER), *Enseñanza de las Ciencias*	4
International Research in Geographical and Environmental Education (IRGEE)	3
Social Sciences, *Education Sciences*, *Revista Mexicana de Investigación Educativa*	2
Acta Chimica Slovenica; *BMC Psychiatry*; *Children's Geographies*; *Climate*; *Culture and Education*; *Current Research in Environmental Sustainability*; *Ecopsychology*; *Environmental Quality Management*; *Estudos de Psicologia*; *Frontiers in Psychology*; *International Journal of Behavioral Development*; *International Journal of Disaster Risk Reduction*; *Journal of Environmental Accounting and Management*; *International Journal of Science Education*; *Investigações em Ensino de Ciências*; *Jàmbá: Journal of Disaster Risk Studies*; *Journal of Cleaner Production*; *Journal of Environmental Psychology*; *Journal of Geography*; *Journal of People, Plants and Environment*; *Journal of Public Health and Development*; *Learning and Individual Differences*; *Opción*; *Review of International Geographical Education Online*; *Revista Complutense de Educación*; *Revista de Ciencias Sociales*; *Revista Electrónica Educare*; *Social Indicators Research*; *The Journal of Education Research*	1

FIGURE 3. Country of origin of the institutions that have researched secondary education students' comprehension of climate change.

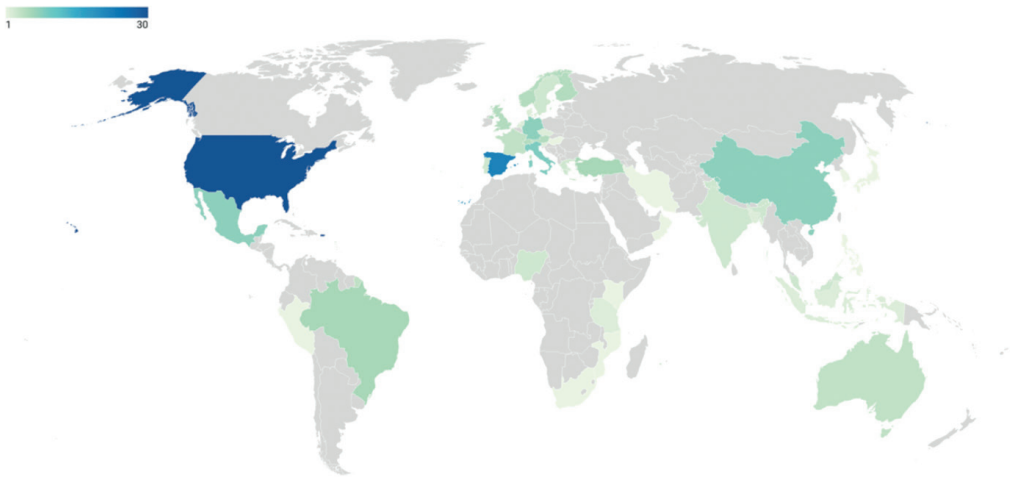


Italy also stands out in this period with 5 studies, as do Finland and Mexico, with 4 each, and Switzerland, Austria, Nigeria, Portugal, and Brazil(which leads the South America region in publications) with 3 studies. Among the newly added countries, Nigeria (the principal exponent in Africa) and Portugal, Czechia, and Slovenia, with 2 current publications each, also stand out.

So, the principal research activity is located in North America and Europe (Figure 4), which (apart from Eastern Europe) are responsible for the majority of the studies, 73.9% of the total.

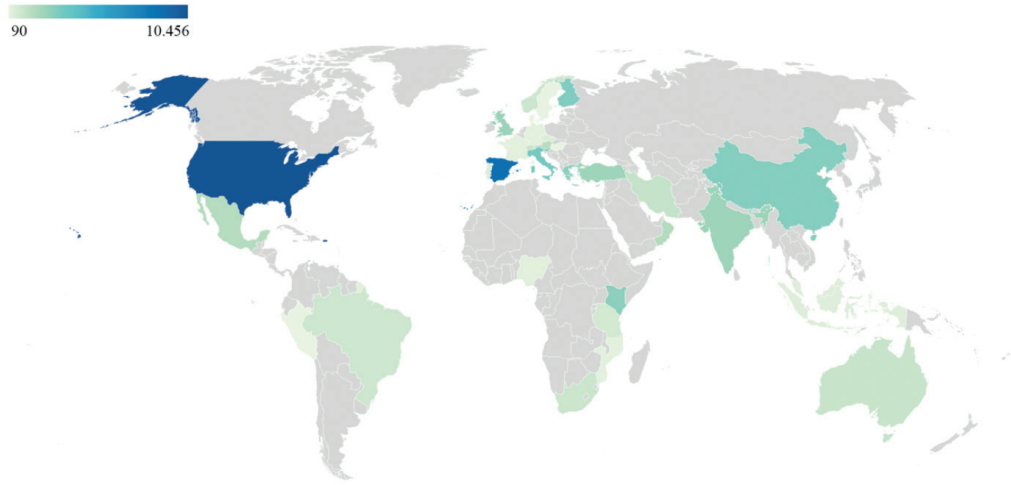
The other geographical regions are principally represented in Asia by China, India, and Turkey (9.8%) (east, south and west, respectively), while Australia, the Philippines, Indonesia, Malaysia, and Singapore produced 12 studies in south-east Asia and Australia (6.9%). The majority of the studies from Africa are from countries in the south and east such as Kenya, Tanzania, Mozambique, and South Africa, which, along with Nigeria, represent 4% of the universities that have carried out research.

Figure 4. Number of studies carried out and country of origin of the research institutions (1993–2024).



On the other hand, Figure 5 offers an overview of the international scope of the research, in this case considering the provenance of the students participating in the studies. In total, more than 56 000 students from 36 nationalities participated, with 65% of this population concentrated in North America and Europe.

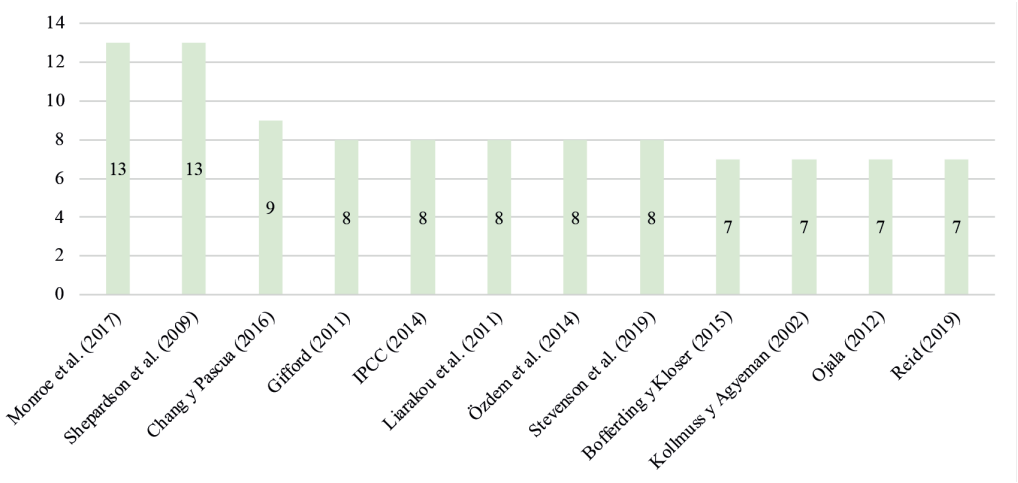
Figure 5. Secondary education students who have participated in studies on comprehension of climate change (1993-2024).



3.2. Bibliographic statistics

More than 3000 bibliographic references were counted, reflecting the trends, key documents, and schools of thought that guide this field of research. Figure 6 shows the 12 most-cited documents in the inventory of studies in this review. First place in the ranking is shared by the study by Shepardson et al. (2009) and the systematic review by Monroe et al. (2017), with 13 references each. On the one hand, the work of Shepardson et al. (2009) is a key study in the trajectory of educational research into secondary education students' comprehension of CC. On the other hand, the work by Monroe et al. (2017), which examines the literature to identify studies that describe and assess effective educational activities on CC, has had a significant impact in scientific literature in the last seven years. They are followed by the study by Chang and Pascua (2016), on the same line as the study by Shepardson et al. (2009), with 9 citations. This work by the current editor of the journal *IRGEE*, Chew-Hung Chang, shows that research

FIGURE 6. Most-cited documents in the 2017-2024 period.



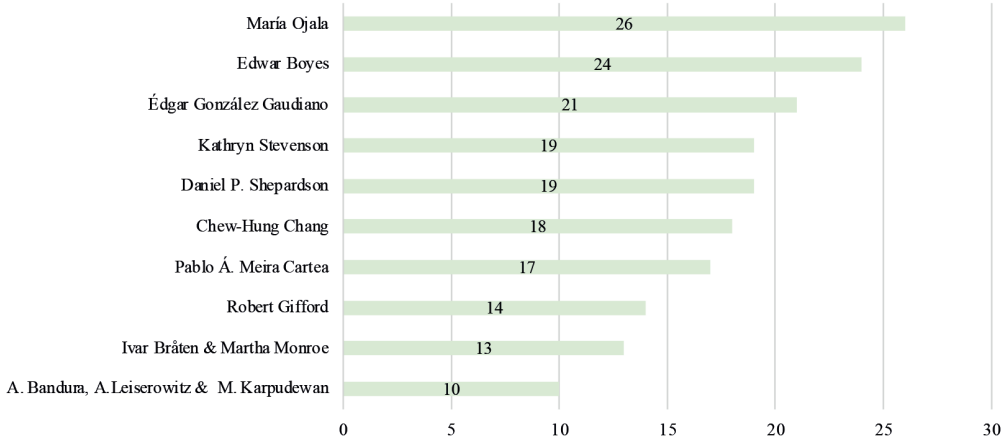
in relation to alternative conceptions of CC is still relevant, even though there is a large amount of literature on this topic.

Third place in order of citations is held by five studies with eight citations each. This group of studies represents lines of interest within the field of research. In this way, Robert Gifford (2011) is point of reference in environmental psychology with his study on the psychological barriers that hinder or impede decision making on decarbonised behaviours in everyday life. The IPCC's reports again appear as the most used documents to validate the scientific foundations of CC, in particular the report of Working Group III which is responsible for examining and assessing the possibilities of mitigation (IPCC, 2014).

On another note, the studies by Liarakou et al. (2011) and Özdem et al. (2014) follow the line of research initiated by Daniel Shepardson and Edward Boyes (García-Vinuesa & Meira-Cartea, 2019) by exploring students' comprehension or beliefs and serving as key works to establish the state of the question of other similar research works. The study by Kathryn Stevenson and her team from North Carolina State University, in the USA, stands out, suggesting a shift in the scientific community's interest in other cognitive aspects of climate action beyond the conceptual content. In this case, attention is centred on the sense of concern generated by the climate crisis as a catalyst for pro-climate actions and their possible links to the close environment of adolescents in the US (Stevenson et al., 2019).

Finally, there is another group of four studies with seven citations. One of them, aligned with the studies by Liarakou et al. (2011) and Özdem et al. (2014), focuses on comprehension of CC (Bofferding & Kloser, 2015). For their part, Kollmuss and Agyeman (2002) analyse different explanatory behavioural models to identify decisive aspects of environmental behaviours, while Maria Ojala (2012) is a reference figure with regards to the emotional dimension of CC. Finally, the article by Alan Reid, editor of EER, outlines his journal's future editorial line in relation to what he calls climate change education in a study of the possibilities and obstacles of education and research in this regard (Reid, 2019).

Figure 7. Most cited authors in the 2017-2024 period.



When focusing the analysis on main authors, the scenario changes. Figure 6 presents the most cited authors, considering only those authors who are listed as lead authors and excluding self-citations.

Two women stand out in this analysis of the 2017–2024 period: Maria Ojala, who appears as the most cited author, climbing eight places compared to the 1993-2017 period, and Kathryn Stevenson in fourth place with 19 citations. Both authors represent and reinforce the hypothesis of a paradigm shift in educational research, consolidating interest in the emotional dimension as an essential aspect in the search for mitigation and adaptation proposals in education. In relation to the results of the previous review by García-Vinuesa and Meira-Cartea (2019), only three authors (and their teams) are still in this ranking: Edward Boyes, Daniel Shepardson, and Anthony Leiserowitz, representing authentic well-established schools of thought in this field of research that have promoted and collaborated with a new generation of researchers under their supervision. On the other hand, the presence in this ranking of Robert Gifford and Albert Bandura highlights the importance of contributions from psychology in this educational field.

Finally, in this analysis it is worth noting the incorporation in this ranking of two significant researchers in the expansion of research in environmental education and CC in the context of Latin America and Iberian Peninsula: Édgar J. González-Gaudiano in Mexico (Universidad Veracruzana) and Pablo Á. Meira-Cartea in Spain (Universidad de Santiago de Compostela). Their contributions have served to explore the educational reality of CC in Spain and Mexico

from the framework of social representation theory and from more critical environmental education focuses, generating significant collaborations on both sides of the Atlantic.

4. Discussion and conclusions

In the era of the climate emergency, educational research's interest in CC seems to be sustained and to be opening up horizons in different aspects relating to the study of its comprehension by secondary education students.

On the one hand, with regards to geographical context, studies have been identified in 12 new countries: Slovenia, Philippines, Hungary, Japan, Kenya, Mozambique, Nigeria, Peru, Portugal, Czechia, South Africa, and Tanzania. Although no definite pattern can be established, these results underline the importance of educational research addressing the specific and contextual needs of the groups studied. The increase in the diversity of the participating student population suggests that this field values the exploration of contextualised realities, as recommended by studies and international reports (United Nations, 2015a; Monroe et al., 2017), with the aim of offering effective educational responses that are adapted to the climate emergency. This interest is also reflected in the fact that the research published over the last seven years has tripled the number of students who have participated in this type of study compared with the previous two decades (García-Vinuesa & Meira-Cartea, 2019), principally driven by the increase in quantitative studies, which represent 67% of the studies in this period compared with 46% in the 1993-2017 period, thus making it possible to access a larger population. These results represent a valuable contribution to knowledge of this group's perception of the climate emergency.

Another notable aspect relates to the focus and priorities of research into education and climate change. The analysis of the most referenced documents suggests a paradigm shift towards what we could consider to be education for the climate emergency and not for climate literacy. In this sense, the theoretical article by Reid (2019) sets out a series of recommendations directed towards both research and teaching-learning in what he calls *climate change education* in a situation of emergency. An education that should be based on ethical positions that ensure global climate justice. Under this premise, it is necessary to make the root of the causes of the problem visible from an outlook that is interdisciplinary and multidisciplinary, local and global, with social and holistic learning processes that address the uncertainty surrounding the causes and possible solutions of mitigation and adaptation. We agree with Reid (2019) that education for climate change in times of climate emergency requires integration of the values and beliefs of educators and students, considering the circumstances of their everyday lives and the influences of culture, class, gender, and personal beliefs that affect perceived risk and coping strategies. It is vital to use evidence and foster critical thinking to confront denialist ideologies and cognitive biases, and deal with difficulties understanding the huge amount of information that is held and is generated in current society. Also, strategies should be developed that promote leadership and collaboration by all of the stakeholders in the educational community, overcoming obstacles such as polarisation and scepticism, and adapting situations and proposals for action so that socioeducational policies can respond to the complex challenges of the climate emergency. This focus is also apparent in the contributions by the studies of Maria Ojala relating to the emotional dimension of the problem, or Kathryn Stevenson, on experiences and perceptions of concern, that open new horizons for a pedagogy for the climate emergency.

In conclusion, international effort from the field of educational research in relation to CC and its comprehension by adolescent students is notable, with institutions from a total of 39 countries having proposed and carried out research. We acknowledge that it is certain that other pieces of research will have been published that have not been identified in this systematic scoping review. In this analysis, the cases of countries such as Canada or Russia stand out as they have advanced research systems but are not represented in this review. This could, as we noted above, be because of linguistic limitations, but it could also be because their institutions and researchers use editorial circuits that are not connected to the selected databases.

It should be mentioned that the analyses presented have been limited by questions of scope and there are still many data to analyse in this collection that can guide future studies and proposals. Even so, the results presented, along with the work of García-Vinuesa and Meira-Cartea (2019), offer an inventory of studies that make it possible to respond to the objectives of this study and provide an overview of the characterisation of this topic, in particular over the last three decades.

With it, we seek to make a wide array of findings and evidence available to the scientific and educational community that can be useful both in research (identifying schools of thought, networks of collaboration, states of the art, trends, new horizons, etc.) and in educational policies and practices (helping to make informed decisions, suggesting new teaching and learning methodologies, recognising difficulties and opportunities, and references of interest).[1]

Authors' contributions

Marta Segade-Vázquez: Conceptualisation; Data curation; Formal analysis; Methodology; Research; Visualisation; Writing (original draft); Writing (review and editing).

Antonio García-Vinuesa: Conceptualisation; Data curation; Formal analysis; Funding acquisition; Methodology; Research; Validation; Visualisation; Writing (original draft); Writing (review and editing).

Ana Rodríguez-Groba: Conceptualisation; Project administration; Research; Supervision; Validation; Writing (review and editing).

Júlio J. Conde: Funding acquisition; Visualisation; Writing (review and editing).

Artificial Intelligence (AI) Policy

The authors do not claim to have made use of Artificial Intelligence (AI) in the preparation of their articles.

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Authors' biographies

Marta Segade-Vázquez. Graduate in Biotechnology from the Universidad de Santiago de Compostela. In 2021, she started her research activity in molecular microbiology through periods with various groups at the university. She completed her education with a Master's in Virology at the Universidad de Valencia and a period as a research assistant at the Biomedical Institute of Valencia (IBV) of Spain's Higher Council for Scientific Research (CSIC), where she specialised in macromolecule crystallography. In 2023-2024, she did a Master's in Obligatory Secondary Education Teaching at the Universidad de Santiago de Compostela, specialising in experimental sciences.

https://orcid.org/0009-0007-1445-9073

Antonio García-Vinuesa. Telecommunications Engineering Degree from the Universidad de Castilla-La Mancha (2017), Undergraduate Degree in Primary Education (2016), Master's in Research in Education (2017), and doctorate in Education (2021) from the Universidad de Santiago de Compostela (USC). His research interests are in the framework of environmental Education and, in particular, the search for educational and social responses to the climate emergency. He does his research in the social pedagogy and environmental education, SEPA-interea research group at USC.

https://orcid.org/0000-0003-3969-4647

Ana Rodríguez-Groba. Degree in Pedagogy in 2011 (End of Course Prize from the Xunta de Galicia) and in Educational Psychology (2013) from the Universidade de Santiago de Compostela. She completed her education with the University Master's in Education Processes (2013). In the same year she started her research career after obtaining a university teacher training predoctoral contract (FPU) and in 2019 she presented her thesis *Enseñanza con redes sociales y aprendizaje autorregulado. Un estudio de caso en la universidad (Teaching*

with social networks and self-regulated learning. A university case study) (Special Doctoral Prize from the Universidad de Santiago de Compostela). She has participated in national and European projects that have technology and/or didactics as their main axis. Since 2020 she has held the position of assistant professor in the Department of Pedagogy and Didactics, in the Area of Didactics and School Organisation in the Faculty of Educational Sciences at the Campus Vida, Santiago.

https://orcid.org/0000-0001-6372-6851

Júlio J. Conde. Doctorate in Chemical Engineering from the Universidad Complutense de Madrid, with a thesis in the field of hydrogen-based renewable energies. In his postdoctoral stage, both in private companies and in universities, he worked on product life-cycle analysis and processes, as well as on advanced oxidisation processes in the field of waste water treatment. In 2023 he joined the SEPA-interea group as a Juan de la Cierva postdoctoral researcher, centring his research activity on climate change education and on the socioeducational potential of the interface between environmental education and the energy transition.

https://orcid.org/0000-0001-8739-6893