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Review

Secondary Education Teachers and Climate Change Education: A Complementary Bibliometric and Methodological Review

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Abstract

Climate change is the most significant socio-environmental challenges of our time, and education has been recognized as a fundamental strategy to confront it. Yet research efforts have focused more on students than on teachers, despite the latter's key role in mediating between scientific and curricular knowledge and classroom practice. This study set out to characterize the field of educational research on climate change from the perspective of secondary school teachers. To this end, we conducted a systematic review and bibliometric analysis of 50 peer-reviewed studies from 15 countries (2010–2023). The results show a growing interest over time, with increases associated with international milestones such as the IPCC reports and the Paris Agreement, while declines are observed in connection with political shifts and the COVID-19 pandemic. Consolidated academic reference points were identified, including Eric Plutzer and Maria Ojala, alongside influential international organizations such as the IPCC and UNESCO, suggesting the presence of schools of thought and institutional frameworks that structure the field. Methodologically, descriptive and exploratory studies predominate, with a notable reliance on qualitative and mixed-methods designs using small samples, reinforcing the difficulty of accessing teachers as a research population. Overall, this review highlights significant gaps, particularly the geographical bias toward the Global North, and underscores the urgency of broader, more inclusive, and critically engaged research that positions teachers as essential agents of transformative educational responses to the climate crisis.

Keywords: systematic review; climate change; education; teacher; middle school; high school; global warming

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1. Introduction

The environmental movements that emerged in the second half of the 20th century initiated a trend that has gained strength over the last 50 years, denouncing the consequences of human activities on the environment. As a result of this movement, international conferences were held to discuss climate change driven by human activities and their implications for the planet, with a view to addressing the needs of both present and future generations.

Following these conferences, important environmental policies were implemented globally and locally to regulate actions to combat climate change, with environmental education integrated as a fundamental strategy in this response.

However, the efforts made towards environmental protection have been uneven across the planet due to different circumstances, but mainly because these environmental policies are at the mercy of neoliberal economic dogmas strengthened by globalization that, at times, paradoxically reinforces an economic model that is at the deepest roots of the environmental crisis [1].

The creation of the Intergovernmental Panel on Climate Change (IPCC) aimed to disseminate scientific data on the state of the climate and future scenarios resulting from greenhouse gas emissions from human activities. However, although civil society's response was partly skeptical, there is no scientific evidence to deny that one of the agents of climate change is humankind itself [2]. The influence of human activities on the climate is a complex phenomenon. It involves the means of producing energy and consumer goods, as well as the level of consumption we adopt across a wide range of sectors. The result is a complete imbalance in the natural environment. Climate change is already a reality, deepening social inequalities and promoting unequal access to a balanced environment and minimum subsistence conditions for thousands of people around the world, as well as the migration of entire populations.

To address climate change, a critical analysis of its causes is necessary, establishing the fundamental connection between the hegemonic developmentalist culture and its consequences for the planet, to enable the continuity of life for our species and so many others in a way that is respectful and dignified with the complex system that is Gaia.

Education, as one of the essential coping strategies (though not the only one), must address the different dimensions that make environmental issues, especially climate change, complex. Therefore, environmental education needs to overcome naive theories and distorted concepts about the causes of climate change [3,4] and go beyond climate literacy, directing its efforts toward developing critical thinking skills that link understanding the causes and consequences of climate change with participatory problem-solving capacity [1].

Recognizing the importance of critically addressing climate change in basic education, we aim to expand on García-Vinuesa's research [5]. Through a systematic literature review, the author sought to broaden his understanding of the evolution of climate change education from teachers' perspectives. To this end, he conducted research on how secondary and high school teachers addressed climate change in their teaching. This work is relevant because there is a lack of reviews that target teachers. Conversely, the large number of publications targeting future teachers or students is notable.

García-Vinuesa [5] observed a strong geolocalized bias toward the global North, as only one Latin American paper was included in the search. Our hypothesis for this result is based on two aspects. The first is that the field of construction and dissemination of academic knowledge, such as universities and journals (both national and international), is not immune to the global logic that shapes virtually everything aimed at differentiating the global North and the South. A second point aligns with the neoliberal rationale of competition in many areas. Combining these two ideas and aligning with Paniagua Roldán [6], we understand that Latin American journals are undervalued in the most relevant international indexes, while English-language publications from countries in the global North, primarily those in the so-called hard sciences, are overvalued. The limited presence of Latin American journals in these indexes is reflected mainly in their lowest quartiles, according to the instruments that rank the quality of journals in the academic elite.

Therefore, the present study does not constitute an independent review but is explicitly grounded in García-Vinuesa's [5] previous work, which provided a thematic analysis of the field. That earlier review highlighted a notable geographical bias in scientific produc-

tion, particularly the limited representation of Latin American research. However, due to its scope and structural constraints, it was not possible to systematically explore the bibliometric dimension of the corpus or the methodological characteristics of the analyzed studies. Building on this foundational thematic synthesis, the present study extends and complements the previous review by expanding the databases to include journals indexing Latin American research and by incorporating a bibliometric and methodological analysis, enabling a quantitative and structural examination of publication trends, geographical distribution, methodological designs, and thematic orientations.

This review addresses two key questions: (1) What are the main publication trends and geographical patterns in this field? and (2) which methodological approaches predominate in the analyzed studies? Its aim is to systematically map the literature on climate change education for secondary teachers, providing an integrated overview of both quantitative trends and methodological approaches. By identifying publication patterns, geographic distribution, and prevailing study designs, it highlights research gaps and underexplored areas to inform future investigations. Importantly, by complementing García-Vinuesa [5], whose review provides a thematic analysis, this study forms an inseparable framework with the previous work, combining methodological and thematic insights to deliver a more complete and nuanced understanding of the evolution, current landscape, and research practices within this domain.

2. Materials and Methods

The original review [5] followed methodological recommendations for conducting scoping reviews [7] and was implemented using the CADIMA v.2.2.4.2 web-based platform, which guided all protocol stages. That review addressed the research question: What challenges and opportunities for promoting CCE among secondary education teachers emerge from the literature? The search was conducted using English and Portuguese keywords under the following strategy: (TITLE-ABS-KEY (“climate change” OR “global warming”) AND TITLE-ABS-KEY (“teacher” OR “professor*”) AND TITLE-ABS-KEY (“secondary” OR “school*”) AND NOT TITLE-ABS-KEY (“elementary school*” OR “pre-service teacher*”)). A thematic analysis was applied to the selected studies.

Five inclusion and exclusion criteria were applied, focusing on studies involving middle and high school teachers, with content related to climate change education, and published in English, Spanish, or Portuguese. Only peer-reviewed journal articles were considered. The search, conducted in the Web of Science (WOS) and Scopus databases on 23 February 2023, was complemented by manual screening of reference lists from relevant reviews. Consistency checks were carried out across multiple screening rounds to ensure high inter-reviewer agreement. The methodological procedures and screening protocol are reported in detail in the previous review [5], which serves as the basis for the present study.

In this updated review, we expanded the search strategy by incorporating the Scientific Electronic Library Online (SciELO) database, which indexes leading Latin American scientific journals, to address the geographic bias identified in the previous review. Accordingly, the present study extends the dataset of García-Vinuesa [5] through the inclusion of additional records indexed in SciELO. This additional search was performed on 22 July 2025 using the same inclusion and exclusion criteria as the original review, but this time using Portuguese and Spanish keywords, under the following search string: (TITLE-ABS-KEY (professor OR profesor* OR educador* OR docente*) AND (climatic* OR aquecimento* OR calentamiento*) AND (educação* OR educación* OR ensino*)). While the dataset partially overlaps with that of the previous review, the current analysis adopts a bibliometric and methodological perspective rather than a thematic approach. This shift enables the identification of influential authors, journals, collaboration networks, and methodological

trends in the field. The updated search yielded eight additional studies, which were integrated into the bibliometric analysis to explore new patterns and developments since the original publication.

2.1. Data Extraction and Analytical Framework

To collect, synthesize, and organize targeted information to characterize the research field, two main categories of analysis were established: bibliometric and methodological. Data extraction was conducted using CADIMA, while Microsoft Excel was employed to structure the database and perform descriptive and bibliometric analyses:

- Bibliometric variables: These included the author's name, gender, year of publication, institutional affiliation, publication language, journal, publisher, citations scores, and keywords. Descriptive statistics were applied, and the results are displayed in tables and graphs. Additionally, we analyzed the frequency of cited authors and journals to identify the most influential contributors and publication venues in the dataset. The findings were synthesized into visual formats and summarized in an interpretative report.
- Methodological variables: These referred to the type of methodological design, instruments or techniques used for data collection, sample sizes, and participants' nationalities. Descriptive statistics were employed again, with the results presented in tables and graphs. Furthermore, we examined the distribution of qualitative, quantitative, and mixed-methods approaches, as well as the prevalence of specific data-collection tools (e.g., surveys, interviews, content analysis). This analysis provides a comprehensive overview of the research strategies adopted in the selected studies.

2.2. Reporting Bias and Certainty Assessment

In the first selection process (Figure 1), two major international scientific databases—WOS and Scopus—were selected under the assumption that the collected records meet quality standards and provide confidence in the evidence base. Given that assessing study quality in the educational field is particularly challenging, no formal quality assessment was conducted. However, conducting a literature review inherently involves certain biases and limitations. In this case, the primary limitation was geographical bias [5]. To address this, a second selection process was conducted using the SciELO database, which indexes leading Latin American, Portuguese and Spanish scientific journals, resulting in the inclusion of eight new papers. Secondly, because the eligibility criterion required only peer-reviewed journal articles, certain works that align with the aim of this scoping review—such as book chapters (e.g., [8]) and conference proceedings—were excluded. Thirdly, the authors' language proficiency introduced another potential bias, as only works written in English, Spanish, and Portuguese were included. As a result, 61 records written in other languages were excluded, including Korean (39), Russian (5), French (3), Turkish (3), Afrikaans (1), Norwegian (2), Slovenian (2), Dutch (2), Persian (1), and Thai (1). Some records were also listed as "unspecified" (3). This highlights an almost unavoidable language bias: although a previous review identified a bias in Latin American research that we were able to partially mitigate in this updated review (thanks to the authors' linguistic competencies), these 61 studies could potentially provide valuable insights but were excluded due to language constraints.

Finally, regarding methodological considerations, defining a search string for a systematic review—particularly within the field of education—requires a careful balance: it must be broad enough to capture relevant studies, yet focused enough to avoid generating an unmanageable number of results. Within this context, at least one relevant study [6] was initially excluded by the search protocol but was later identified through the reference

lists of previous reviews. This study, published as an "insight" letter, lacks an abstract and does not mention climate change in its title, which led to its omission. To help minimize these limitations, the final sample was reviewed by colleagues in the field of environmental education research. As a result of this external validation, two additional studies were included.

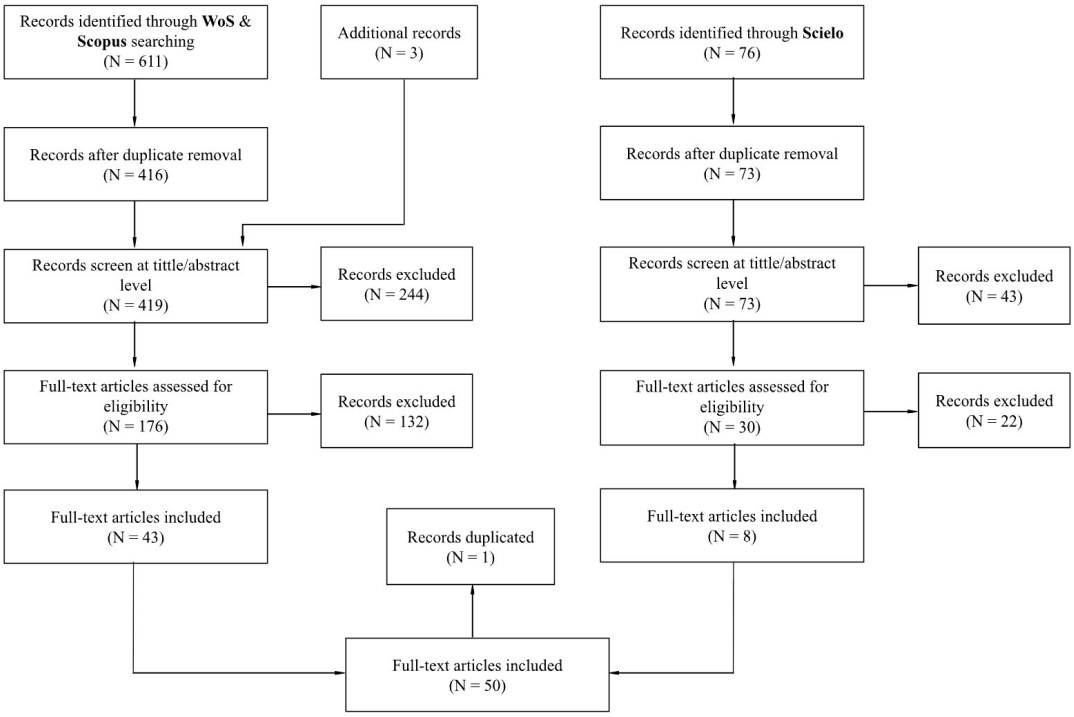

Figure 1. Selection process: flow diagram updated. Adapted from García-Vinuesa [5].

3. Results

As shown in Figure 1, the previous review [5] retrieved 324 records from Scopus and 287 from WOS, for a total of 611. After removing duplicates (both automatically and manually), 416 records remained. Following title and abstract screening, 244 records were excluded for not meeting the eligibility criteria, leaving 176 for full-text in-depth reading. At this stage, 132 records were further excluded, resulting in 44 records.

In parallel, 76 records were identified through the SciELO database, of which three were removed as duplicates. The remaining 73 records underwent title and abstract screening, during which 43 were excluded, leaving 30 for full-text review. After this final screening, 22 records were excluded, retaining eight.

Finally, comparing the results from both review phases, one additional record was excluded, yielding a final sample of 50 studies.

3.1. Analysis of Bibliometric Variables

Table 1 provides a detailed summary of the data extracted from the bibliographic analysis.

Table 1. Bibliographic data.

Study	Year	Gender	Affiliation	Country	Journal	Publisher
[9]	2023	F, F, F	Superior School of Education João de Deus & U. of Lisbon	Portugal	Sisyphus—Journal of Education	U. de Lisboa. Instituto de Educação
[10]	2022	M, M, M, M	Northeast U, .GD, U. of Adelaide & Shahjalal U. of Sci. & Tech.	BGD, Australia,	Frontiers in Climate	Frontiers
[11]	2022	M, M, M	U. of Nigeria	Nigeria	Science Teacher Educ.	Wiley

Table 1. *Cont.*

Study	Year	Gender	Affiliation	Country	Journal	Publisher
[12]	2022	M, M, M, F, F	U. of Fort Hare	South Africa	IJLTER	Society for Res. & Knowl. Manag.
[13]	2022	F, M	Florida Gulf Coast U.	USA	Science & Educ.	Springer
[14]	2022	M, M, M, F	Kwame Nkrumah U. of Sci. & Tech., U. of Energy and Nat Resources & Forestry Res. Inst. of Ghana	Ghana	Sustainability	MDPI
[15]	2022	F, M, F, M	U. Nacional & Technology Institute of Costa Rica	Costa Rica	Uniciencia	Universidad Nacional de Costa Rica
[16]	2021	F, M	U. Federal do Río Grande do Norte	Brazil	Educar em Revista	U. Federal do Paraná
[17]	2021	F, F, M, M	U. of Nebraska-Lincoln, Ctl Washington U., Columbia U. & U. of Texas	USA	J. of Geoscience Educ.	Taylor & Francis
[18]	2021	F, F, F, M, F	U. of Florida, the Pennsylvania State U. & NC State U.	USA	Environ. Educ. Res.	Taylor & Francis
[19]	2021	M, M, M, M	U. of Bristol, U. of Exeter & Department of Science Oldfield School	UK	Environ. Edu. Res.	Taylor & Francis
[20]	2021	F, M	Florida Gulf Coast U.	USA	J. of Science Teacher Educ.	Taylor & Francis
[21]	2021	W	Örebro U.	Sweden	The J. of Environ. Educ.	Taylor & Francis
[22]	2021	F, F	U. of Utah & California State U.	USA	J. of Geoscience Educ.	Taylor & Francis
[23]	2021	F, M	U. of Azuay & U. of Cuenca	Ecuador	ALTERIDAD	Universidad Politécnica Salesiana
[24]	2021	F, F, M	Piauí Federal U.	Brazil	Pre-print	Scielo pre-print
[25]	2021	F	ABC Federal U.	Brazil	Revista Brasileira de Ensino de Física	Sociedade Brasileira de Física
[26]	2020	F, F, F	U. of Passo Fundo	Brazil	Int. J. of Sustainability in H.Educ.	Emerald Publishing Ltd.
[27]	2020	M	U. of Nigeria	Nigeria	Int. Res. in Geogr. & Environ. Educ.	Taylor & Francis
[28]	2020	F, M	U. of Houston	USA	Environ. Educ. Res.	Taylor & Francis
[29]	2020	F, M, M	Ceará State U. & National Institute of Space Research	Brazil	Revista Brasileira de Meteorologia	Sociedade Brasileira de Meteorologia
[30]	2019	M, F	Wright State U.	USA	Climatic Change	Springer
[31]	2019	F, F, F	U. of Maine	USA	Environ. Educ. Res.	Taylor & Francis
[32]	2019	F, F, F	Purdue U. & U. of Nebraska-Lincoln	USA	The J. of Agricultural Educ. & Ext.	Taylor & Francis
[33]	2018	F, F	U. of Florida	USA	Environ. Educ. Res.	Taylor & Francis
[34]	2018	M, M	The Pennsylvania State U. & Wright State U.	USA	Climatic Change	Springer
[35]	2018	M, M, M, F	U. Coll London, UNESCO-IOC, U. of Melbourne	UK, FR, Australia	Int. J. of CC Strategies & Manag.	Emerald Publishing Ltd.
[36]	2017	M, F	Stellenbosch U.	South Africa	Int. Res. in Geogr. & Environ. Educ.	Taylor & Francis
[37]	2017	M	The U. of Adelaide	Australia	Int. Res. in Geogr. & Environ. Educ.	Taylor & Francis
[38]	2017	M	Aarhus U. & VIA U. College	Denmark	Int. Res.in Geogr. & Environ. Educ.	Taylor & Francis
[39]	2017	F, F	U. of Wisconsin–Madison & National Inst. of Educ	USA/Singapore	Int. Res. in Geogr. & Environ. Educ.	Taylor & Francis
[40]	2017	M, M, M, M	Payame Noor U. & U. of Tehran Emerald Publishing Ltd.	Iran	Int. J. of CC Strategies & Manag.	Emerald Publishing Ltd.
[41]	2017	F, F, F	Western Michigan U.	USA	Int. J. of Science Educ.	Taylor & Francis
[42]	2017	F	James Cook University	Australia	Curric Perspect	Springer
[43]	2017	F, F, F	U. of Maine, Bio-Rad Labs & Wiley H. Bates Middle School	USA	Environ. Educ. Res.	Taylor & Francis
[44]	2016	F	Åbo Akademi U.	Finland	Int. J. of Environ. & Science Educ.	Modestum
[45]	2016	M, M, M, M, F, F	The Pennsylvania State U., National Ctr of Sci. Edu. & Wright State U.	USA	Science	AAAS
[46]	2016	F, M, F	NC State U.	USA	PLOS ONE	Public Library of Science
[47]	2015	M, F, M	Stellenbosch U.	South Africa	South African J. of Educ.	University of Pretoria
[48]	2015	F, F	Oklahoma State U.	USA	J. of Educ. Policy	Taylor & Francis
[49]	2015	F, F	Oklahoma State U.	USA	Geoforum	Elsevier
[50]	2015	M, M, F	U. of Missouri & U. of South Florida	USA	Int. J. of Sci. & Mathematics Educ.	Springer
[51]	2015	F, F	U. of Wisconsin–Madison & Nanyang Technological U.	USA/Singapore	Theory & Res. in Social Educ.	Taylor & Francis

Table 1. *Cont.*

Study	Year	Gender	Affiliation	Country	Journal	Publisher
[52]	2015	F, M	James Cook U.	Australia	Electronic J. of studies in the Tropics	James Cook University
[53]	2014	M, F, F, M, M	U. of Idaho & Oregon State U.	USA	Natural Sciences Educ.	Wiley
[54]	2014	F, F	U. Federal do Vale do Jequitinhonha and Mucuri.	Brazil	Reme	Universidade Federal de Minas Gerais
[55]	2013	M, F	Temple U. & U. of Southern California	USA	Int. J. of Science Educ.	Taylor & Francis
[56]	2013	F, F, M	U. of Florida	USA	Applied Environ. Educ. & Commun.	Taylor & Francis
[57]	2010	F	U. of Colorado	USA	J. of Geoscience Educ.	Taylor & Francis
[58]	2002	M	U. of Reading	UK	Int. J. of Science Educ.	Taylor & Francis

Note: M = Male; F = Female; U. = University; BGD = Bangladesh; Int. = International; J. = Journal; Educ. = Education; Res. = Research; Geogr. = Geographical; Environ. = Environmental.

3.2. Trend Publication

In Figure 2, we present the temporal publication trend, comparing the results of this review (solid line) with those of Segade et al. [59], which examined secondary students' understanding of climate change (dotted line). Although educational research has primarily concentrated on students—with a publication trend nearly three times higher than studies on teachers over the same period ($N_{students}$ = 142 vs. $N_{teachers}$ = 50)—the upward trajectory is similar for both groups, suggesting sustained growth of interest in climate-related topics within education research and among the various actors within school systems. The results also reveal an evident decline from late 2017 through early 2021, after which the upward trend observed before 2017 resumes.

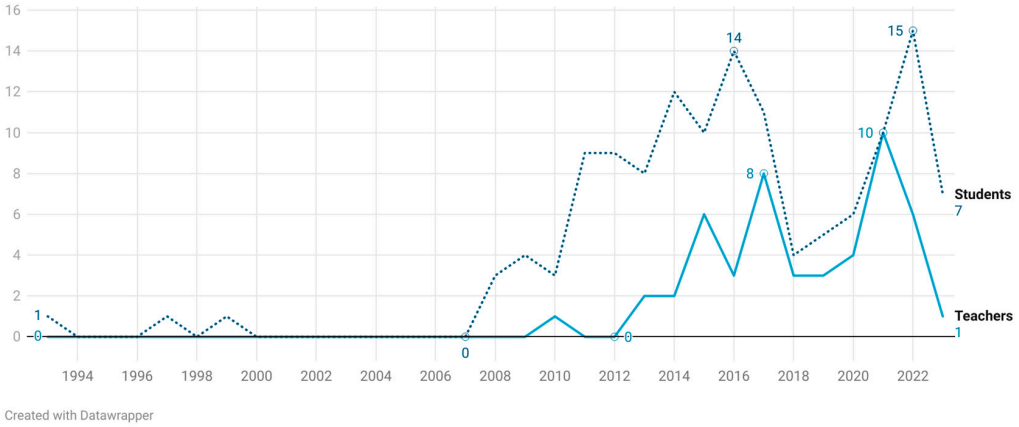

Figure 2. Comparison of publication trends: this review vs. Segade et al. [59].

3.3. Countries and Institutions

The review encompasses contributions from 81 institutions across 15 countries (Figure 3). As shown, U.S. institutions are overrepresented, representing 24 of the 50 studies. Leading institutions include The Pennsylvania State University, the University of Florida, and Wright State University, each contributing three studies. Brazil follows with six studies from different universities, and Australia with five publications, with James Cook University contributing two studies. Compared with the previous review, the use of the SciELO database in the present study led to the identification of seven additional records: one from Portugal [9], one from Costa Rica [15], one from Ecuador [23], and four from Brazil [24,25,29,54].

Regarding inter-university collaborations, studies conducted within a single institution were the most common: 28 in total, compared with 18 national inter-university collaborations and four international collaborations. Although university-based teams led all

studies, nine also involved non-university partners such as research institutes, international organizations, private laboratories, and secondary schools, among other entities.

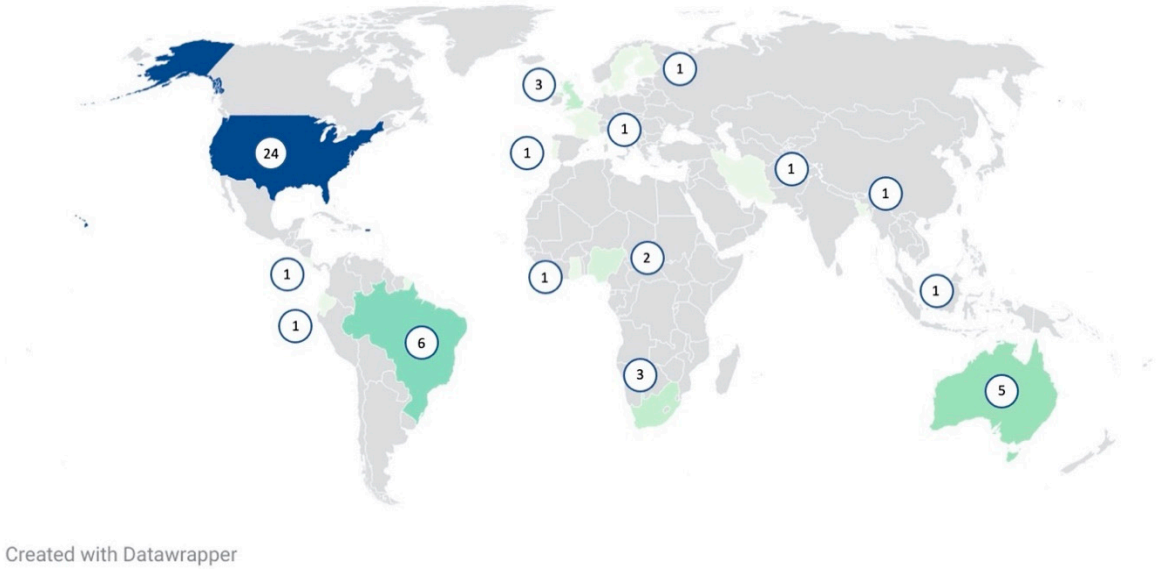

Figure 3. Institutional Countries of Origin in Research on Climate Change and Secondary Education Teachers. The numbers shown in the image indicate the number of studies conducted by institutions from each country.

3.4. Authorship and References

In the 50 studies analyzed, 131 authors participated in collaborations ranging from one to six co-authors (Figure 4). By gender, there were 71 female (54.2%) and 60 male authorships (45.8%). These were distributed as follows: 46.0% of studies were conducted by mixed-gender teams, 36.0% by all-female teams, and 10.0% by all-male teams, while 8.0% were single-authored.

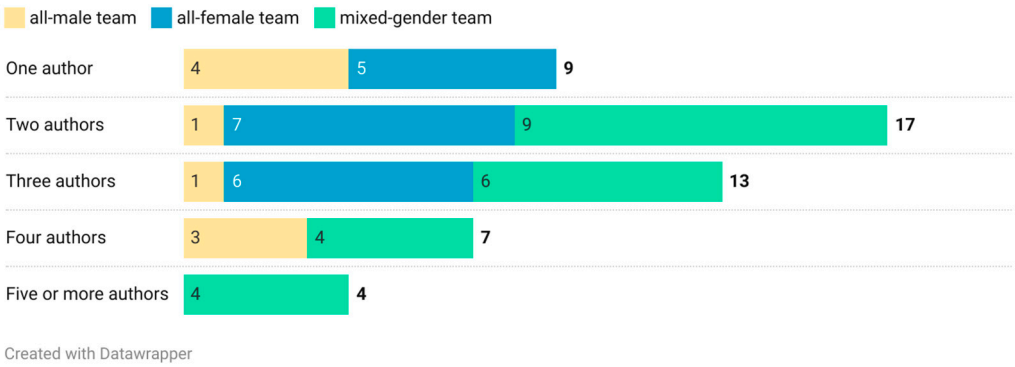

Figure 4. Authorship distribution by gender and team composition.

Regarding citation patterns, Figure 5 presents the 10 most frequently cited authors across the 50 studies in this review, and Figure 6 highlights the 10 most frequently cited first authors.

3.5. Scholarly Publishing Circuit

Figure 7 shows the distribution of journals in which the studies were published, with Environmental Education Research being the most represented journal (six publications). The second most common outlet is International Research in Geographical & Environmental Education (five), highlighting the significant contribution of geographical education to responses to climate change. A third group of journals—International Journal of Science

Education and Journal of Geoscience Education (three each)—further reflects researchers' interest in geoscience and Earth sciences as highly relevant domains for this topic. Fourth, Climatic Change and International Journal of Climate Change Strategies & Management (two each) indicate interest in linking climate-change challenges with their management at levels beyond schools. Finally, the remaining journals, each represented by a single article, illustrate a diversified editorial landscape ranging from high-impact outlets (Science, PLOS ONE, Geoforum) to regional Latin American journals. These results suggest a diverse academic field, where central or highly specialized journals coexist with a wide range of outlets that approach the research problem from interdisciplinary and intradisciplinary perspectives, and at both global and local scales—reflecting the multidimensional nature of the topic.

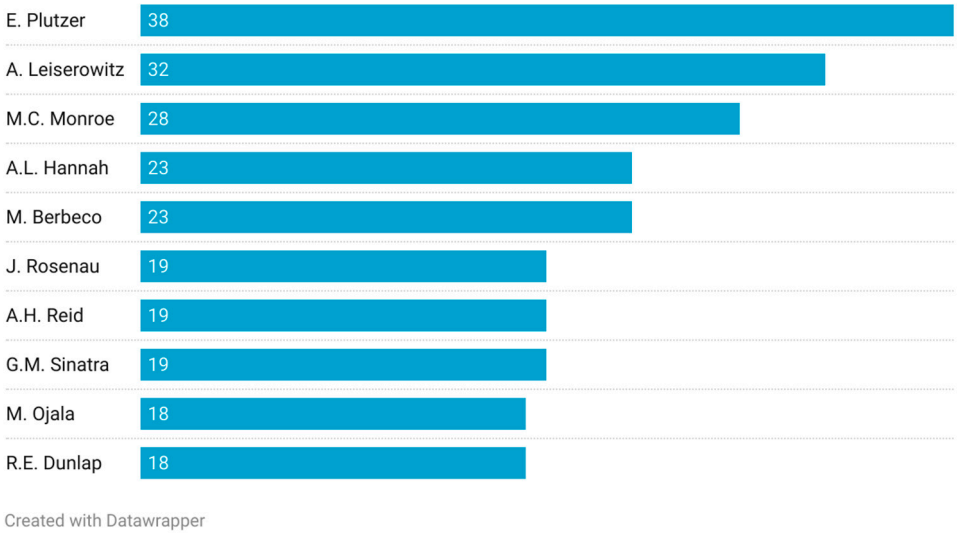

Figure 5. Top cited authors (all positions).

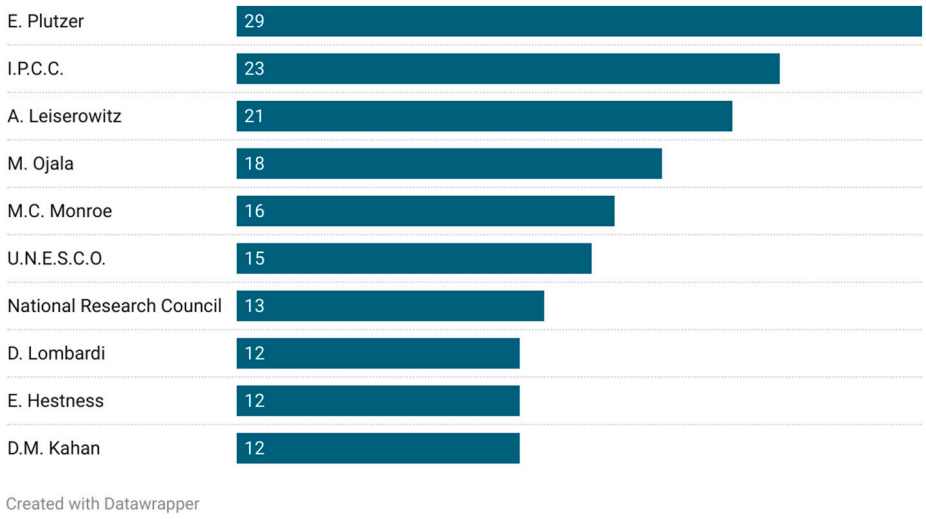

Figure 6. Top cited first authors.

Figure 8 shows that Taylor & Francis is the leading publisher, with 23 publications in the journals included in this review, highlighting its prominent role in the international dissemination of research in this field. It is followed, at a considerable distance, by Springer (5), Emerald (3), and Wiley (2), which together complete the group of publishers with more than one contribution. A third group consists of publishers and institutions represented by a single paper. This category includes both major international publishers, such as Else-

vier, PLOS, MDPI, and Frontiers, and regional publishers or Latin American universities (e.g., SciELO Universidade de São Paulo, Universidade de Lisboa, Universidad Nacional de Costa Rica, Universidade Federal de Minas Gerais). Overall, the data point to a strong concentration among global publishers, while also revealing a broad and heterogeneous landscape of local and regional outlets.

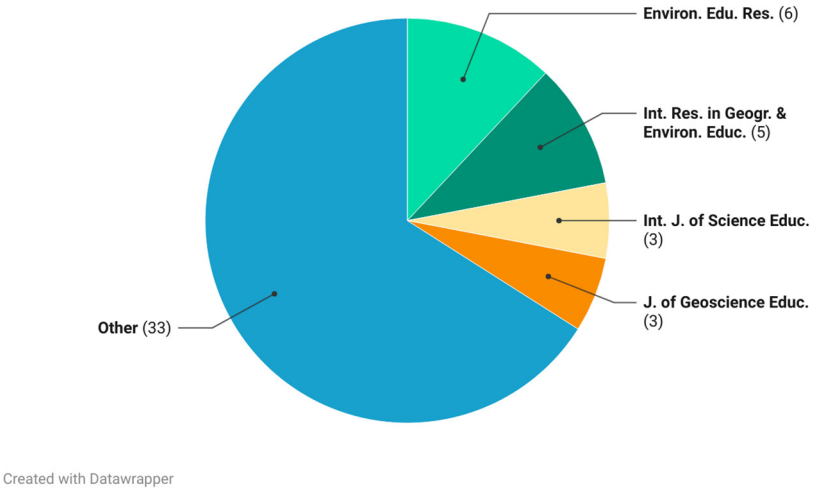

Figure 7. Source Journals of the Reviewed Studies.

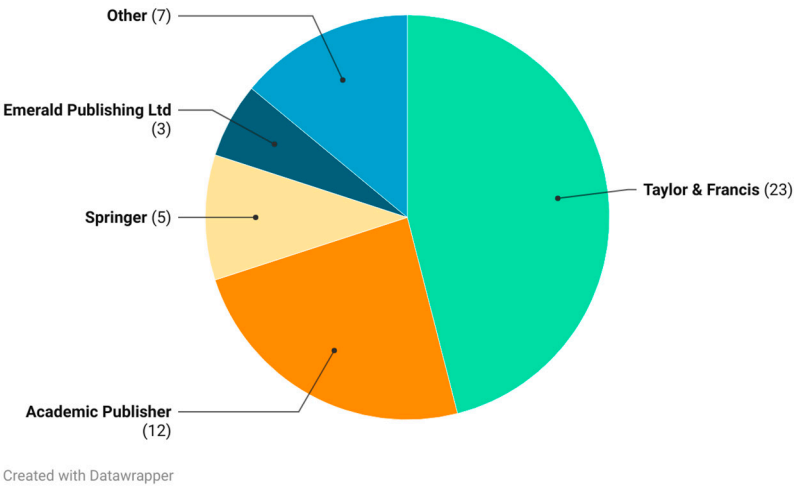

Figure 8. Distribution of Scientific Publishers.

3.6. Thematic Patterns Emerging from Keyword

The purpose of the keyword classification was to identify the thematic interests guiding research within the 50 articles included in this review. After filtering the initial 211 variants, 130 standardized keywords were retained. Classification was based on two criteria: first, keywords were grouped by frequency of occurrence (higher frequency = more intensively studied topics; lower frequency = less studied or emerging perspectives); second, frequency counts were used to define thematic clusters by grouping terms according to their meanings. Eight clusters were established, and their distribution highlights the main areas of focus in this corpus.

Figure 9 presents a graphical summary of the analysis, followed by a block-by-block narrative interpretation.

1. Climate Change (n = 25). This cluster contains the largest number of keywords, indicating, as expected, that climate change is the central focus of the research. It is examined from multiple dimensions, including theoretical knowledge (global warming,

greenhouse effect, climate science literacy), emotional and perceptual dimensions (awareness, perception), risk and resilience to extreme events, and adaptation. This conceptual breadth highlights the importance of addressing climate change from political, social, and educational perspectives.

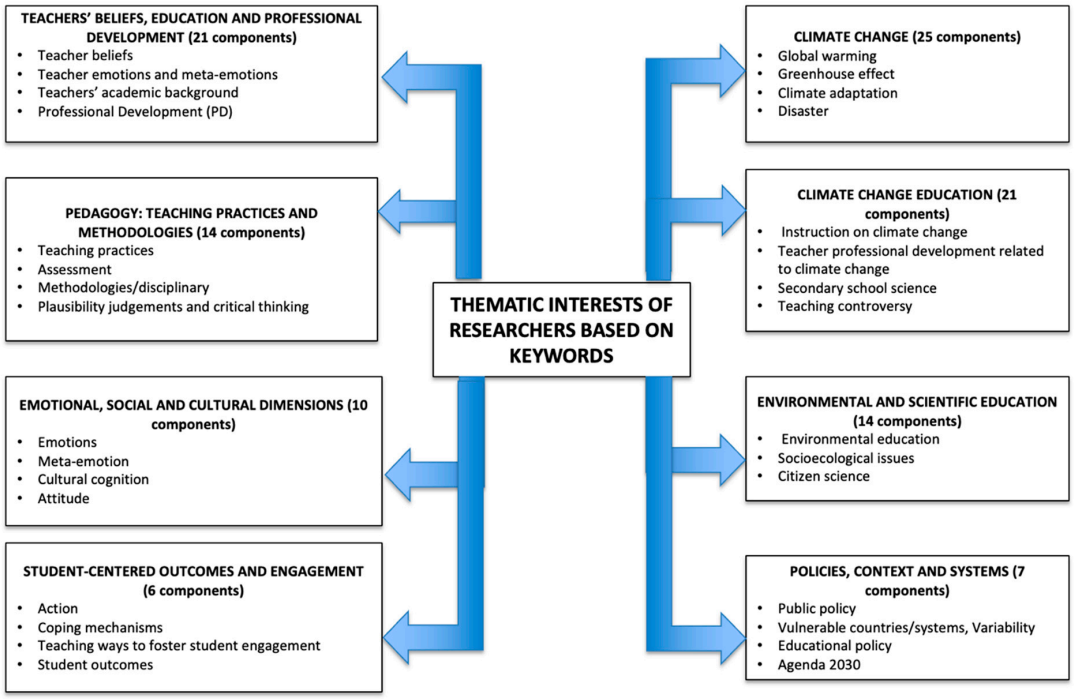

Figure 9. Thematic clusters of research interests identified from the keywords. Source: authors' elaboration.

2. Climate Change Education (n = 24). This cluster reflects interest in approaches to climate change education. It encompasses perspectives on curriculum, standards, teaching methodologies, civic participation (e.g., Fridays For Future), and teacher professional development. The variety of keywords may indicate concern for the effectiveness of educational strategies in fostering a critical and engaged citizenry capable of responding to climate change.

3. Teacher Beliefs, Education & Professional Development (n = 24). This cluster centers on the teacher's role. It emphasizes teachers' conceptions, attitudes, values, emotions, and their initial and ongoing professional development. This focus reflects researchers' recognition of the importance of teachers' ideas, motivations, and training for climate change education.

4. Pedagogy & Teaching Practices (n = 16). This cluster emphasizes the exploration of pedagogical strategies that highlight experimentation and reflection. The associated keywords encompass methodologies, assessment practices, and epistemic tools. The inclusion of terms such as arguments/rebuttals and controversial issues reflects a clear interest in fostering critical thinking.

5. Environmental & Science Education (n = 14). This category prioritizes environmental and scientific literacy through themes such as environmental stewardship, sustainability, citizen science, social ecology, natural sciences, and environmental health. It reflects an intention to align environmental education with broad-based scientific training.

6. Policy, Context & Systemic Issues (n = 11). This cluster highlights concerns about the institutional and contextual frameworks influencing environmental education. It prioritizes understanding how external factors and national and international policies affect the implementation of environmental programs and strategies, as well as identifying the inequalities associated with them. The keywords point to issues such as political

polarization, international standards and agendas (e.g., the 2030 Agenda), and regional differences and vulnerabilities.

7. Emotional, Social & Cultural (n = 10). This cluster highlights the role of emotional, social, and cultural factors in shaping how climate change is understood and conceptualized. It emphasizes the need to address not only disciplinary knowledge or content but also aspects linked to the emotional sphere, such as sense of belonging, identity, and values. Keywords in this cluster include emotions, consensus, resistance, and motivation, all pointing in this direction.

8. Student-Centered Outcomes & Engagement (n = 6). Finally, this cluster emphasizes student outcomes and engagement. Keywords in this cluster include action, scientific practices, and active participation, indicating interest in both understanding and fostering student and teacher agency in educational responses to climate change.

3.7. Analysis of Methodological Variables

This section addresses the methodological approaches employed in the identified studies. Table 2 presents the data extracted for the methodological analysis, as outlined in the methodology. The table includes information on participants' country, method, research type, study type, sample size, and instruments or techniques used. Following Table 2, a detailed analysis of each variable is provided to facilitate interpretation and allow more explicit inferences. The variables analyzed follow the left-to-right order of presentation in Table 2.

Table 2. Methodological data extracted.

Study	N	Country	Method	Research Type	Study Type	Instrument/Technique
[9]	7	Portugal	MM	Multiple-case study	EXP	Interview, questionnaire & participant observation
[10]	4	South Africa	QUAL	Case study	EXP	Semi structured interviews
[11]	95	Bangladesh	QUANT	Survey	DES	Questionnaire
[12]	4	USA	MM	Case study	EXPL/DES/COR	Interview
[13]	100	Ghana	MM	Survey	DES/COR	Questionnaire and content analysis
[14]	410	Nigeria	QUANT	Survey	DES	Questionnaire (Teachers' Climate Change Concepts Needs Assessment)
[15]	9	Costa Rica	QUAL	Survey	EXP	DELPHI Questionnaire
[16]	18	USA	QUAL	Case study	EXP	Essay
[17]	4	USA	MM	Multiple-case study	EXP/DES	Observations, pre/post-interviews, daily reflections, instructional artifacts
[18]	661	UK	QUANT	Survey	DES	Questionnaire
[19]	11	Brazil	QUAL	Case study	EXP	Interview
[20]	4	USA	MM	Case study	EXP/DES	Questionnaire, classroom observations and interviews
[21]	16	Sweden	QUAL	Phenomenological	EXP	Semi-structured interview
[22]	54	USA	QUANT	Survey	DES	Questionnaire
[23]	31	Ecuador	MM	Survey	DES/EXP/CCOR	Questionnaire
[24]	24	Brazil	QUAL	Survey	EXP/DES	Questionnaire
[25]	4	Brazil	QUAL	Case study	EXP/EXPL	Semi-structured interview
[26]	832	USA	QUANT	Survey	DES/COR	Questionnaire
[27]	4	Brazil	QUAL	Survey	EXP/DES	Pre-test, post-test (questionnaire) and observation (content analysis)
[28]	1375	Nigeria	QUANT	Survey	DES	Structured questionnaire
[29]	10	Brazil	QUAL/QUANT	Field research	DES/EXP	Interview
[30]	1500	USA	QUANT	Survey	COR/EXPL	Questionnaire (National Survey of Science Teachers)
[31]	5	USA	QUAL	Case study	EXP	Writing reflections and semi-structured conversational interview
[32]	258	USA	MM	Survey	DES/EXP	Questionnaire
[33]	1500	USA	QUANT	Survey	DES/EXPL	Questionnaire (National Survey of Science Teachers)
[34]	251	USA	QUANT	Survey	EXP/EXPL	Questionnaire
[35]	7	USA	QUAL	Multiple-case study	EXP/DES	Interview

Table 2. *Cont.*

Study	N	Country	Method	Research Type	Study Type	Instrument/Technique
[36]	108	Iran	QUANT	Survey	DES/EXP/COR	Questionnaire
[37]	72	Samoa/Fiji/Vanatu	MM	Case study	EXP/DES	Interactive focus group and questionnaire
[38]	408	South Africa	QUANT	Survey	DES/COR	Questionnaire
[39]	4	Denmark	QUAL	Case study	EXP/DES	Classroom observations (videos) and semi-structured interviews
[40]	18	USA	QUAL	Phenomenological	EXP/DES	Online focus groups
[41]	311/21	Australia	MM	Survey/Case study	DES/EXP	Questionary & interviews
[42]	6	Singapore/Philippines	QUAL	Case study	EXP	Interview
[43]	56	Australia	QUAL	Survey	EXP/DES	Questionnaire
[44]	13	Finland	QUAL	Phenomenological	EXP/DES	Semi-structured interviews
[45]	1500	USA	QUANT	Survey	DES/EXP/EXPL	Questionnaire
[46]	24	USA	QUANT	Survey	EXP/COR	Questionnaire
[47]	377	Australia	QUANT	Survey	DES/EXP	Online questionnaire
[48]	115	USA	MM	Case study	EXP	Questionnaire
[49]	220	USA/Puerto Rico	MM	Survey	DES/EXP/COR	Questionnaire
[50]	115	USA	MM	Case study	EXP	Interview, questionnaire & participant observation
[51]	194	South Africa	QUANT	Survey (cross-sectional)	DES/EXP	Multiple-choice questionnaire
[52]	6	Singapore	QUAL	Case study	EXP/DES	semi-structured interviews
[53]	836	USA	MM	Survey	DES/EXP/COR	Questionnaire, observation & semi-structured interviews
[54]	30	Brazil	QUAL	Survey	DES/EXP	Interview
[55]	675	USA	MM	Survey	DES/EXP	Questionnaire
[56]	40	USA	MM	Survey	COR/EXPL	Questionnaire
[57]	628	USA	QUANT	Survey	DES/COR	Questionnaire
[58]	16–20	UK	QUAL	Case study	EXP/DES	Focus group

Note: QUAL = Qualitative; QUANT = Quantitative; MM = Mixed Methods; EXP = Exploratory; DES = Descriptive; COR = Correlational; EXPL = Explicative; Country = Participants' place of origin.

It is important to note that authors often describe the characteristics of their studies differently. While some explicitly indicate whether their study is exploratory or descriptive, others simply mention the research type, such as "case study" or "survey," without further detail. This challenge in characterizing studies methodologically also arises when defining the "research type" variable, given the varying levels of specificity and the diversity of approaches within educational research. For example, three studies [21,41,44] are classified as phenomenological, creating an apparent asymmetry with broader categories (survey, case study, multiple case study, etc.). However, as Creswell [60] notes, this should not be considered a classification error. Therefore, for this analysis, the category "phenomenological" is used to encompass both phenomenographic and phenomenological studies.

3.8. Number of Participants

Figure 10 shows the distribution of studies by number of participants. For ease of interpretation, the studies from Table 2 are grouped by participant ranges (approximately 13,000 teachers in total). Most studies relied on small samples: 14 included between 1 and 10 participants, and 13 between 11 and 50—consistent with the predominance of qualitative or exploratory approaches with manageable sample sizes. By contrast, studies with more than 100 participants were less frequent: seven fell in the 101–300 range, four in 301–600, five in 601–1000, and four in 1001–2000, respectively. The overall trend suggests a focus on depth and detailed case analysis rather than broad statistical representativeness. Thus, while the results provide rich contextual understanding, they also have limitations in terms of generalizability to larger populations.

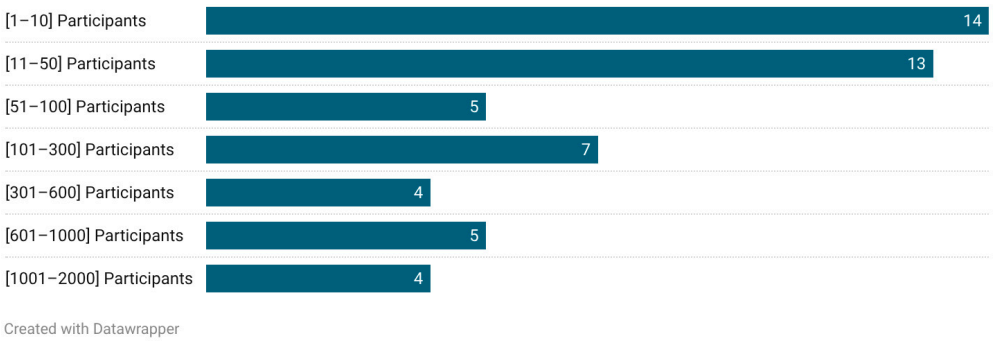

Figure 10. Range of participants.

4. Method

Figure 11 shows the distribution of methodological approaches used in the analyzed studies. Qualitative methods (QUAL) were employed in 19 studies (38.0%), quantitative approaches (QUANT) in 16 (32.0%), and mixed methods (MM) were used in 15 (30.0%). The graphical representation indicates a balance and diversity in methodological choices, with a predominance of qualitative approaches. At the same time, there is evident interest in quantification and methodological complementarity to enhance the robustness and applicability of findings.

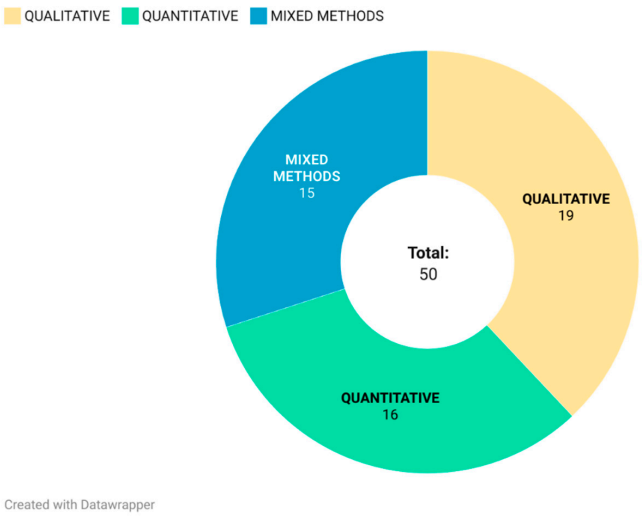

Figure 11. Methodological approaches employed across the studies.

4.1. Research Type

The results show a marked preference for the survey research design, with 26 contributions, suggesting a trend toward standardized instruments and generalizable results. Case studies rank second with 14 contributions. Third, multiple case studies (3) and phenomenological designs (3) were identified. Although categorized differently, both share features with case studies, as they enable qualitative approaches to experiences and meanings. Finally, field research, convergent parallel design, survey/case study, and cross-sectional survey each appear only once. Overall, the findings point to a dual trend: a preference for quantitative approaches applied to broad samples, alongside the use of qualitative, case-based methodologies to deepen understanding of the phenomena under study.

4.2. Study Type

Regarding study type, Figure 12 reveals a clear predominance of descriptive–exploratory designs (DES/EXP), with 19 studies, confirming the tendency to characterize

phenomena and conduct initial explorations of their dynamics. Next are exploratory (EXP) studies, with 10 contributions, and descriptive (DES) studies, with 5, reinforcing their predominance. At an intermediate level are correlational–descriptive (COR/DES) and correlational–descriptive–exploratory (COR/DES/EXP) designs, each with four contributions each, reflecting interest in examining relationships among variables. Less frequent are exploratory–explanatory (EXP/EXPL) and correlational–explanatory (COR/EXPL) designs (two each). Finally, combinations spanning more dimensions, such as DES/EXP/EXPL or COR/DES/EXPL, are rare. Taken together, the research primarily aims to describe and explore, while explanatory and correlational approaches are less common.

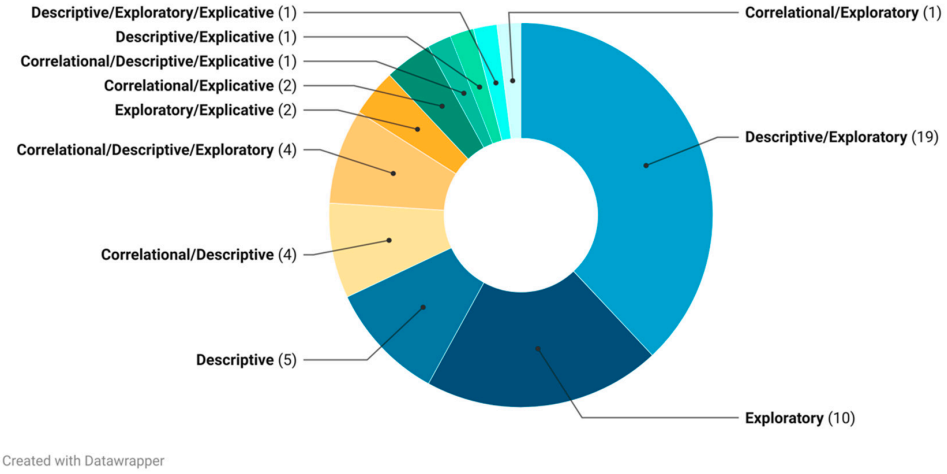

Figure 12. Study type classifications across the reviewed studies.

4.3. Research Instruments

Figure 13 displays the range of research instruments used in the analyzed studies. The results show a clear preference for standardized, scalable techniques. Structured, online, multiple-choice, or Delphi-type questionnaires were most frequently used (50.0%). Structured or semi-structured interviews ranked second (27.9%), reflecting interest in capturing nuances in participants' discourse. Observations with audiovisual support or direct participation followed (10.3%), indicating an effort to record data in context. Less frequently used techniques included focus groups and online interactions (4.4%) and written reflections (2.9%). Finally, occasional techniques such as content analysis, essays, or instructional artifacts appeared in only one study each. Overall, the data indicate a strong preference for traditional, scalable instruments, while qualitative tools complementing them by adding interpretive depth and richness.

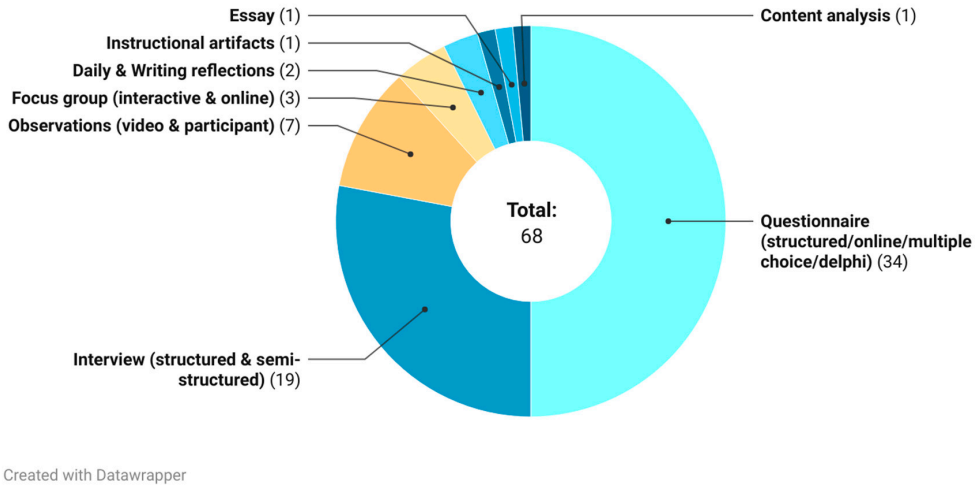

Figure 13. Study type classifications across the analyzed studies.

5. Conclusions

This study aimed to characterize the field of environmental education research addressing the educational implications of climate change, with particular attention paid to studies focused on secondary school teachers. Through bibliographic and methodological analyses, it provides insight into how this specific object of study has been approached in the scientific literature.

Accordingly, we structured our final remarks around three main factors:

5.1. Main Publication Trends

The results on publication trends (Figure 2) confirm a growing interest in climate change education within the educational sciences. The trends observed in this analysis closely mirror those reported by Segade et al. [59], with both studies showing similar peaks and dips over time, suggesting consistent patterns in the evolution of research on education and climate change. Notably, Segade's review on secondary school students shows an initial increase in publications around 2008, whereas the current study focusing on teachers observes the first notable growth in 2013, reflecting a delayed but parallel expansion in research. This rise appears to follow the 2007 IPCC Fourth Assessment Report, which confirmed with high confidence human responsibility for altering the climate system. A peak occurred between 2015 and 2017, alongside the Paris Agreement, which explicitly emphasized the need for educational efforts to address the socio-environmental challenges posed by the climate crisis. However, a sharp decline from 2018 to 2021 reflects shifting political priorities and the impact of the COVID-19 pandemic, both of which redirected attention and funding, resulting in loss of traction on the climate change agenda and impacting the achievement of the Paris Agreement [61]. A subsequent rebound (2021–2022) suggests renewed momentum, possibly linked to new IPCC reports and youth climate strikes. These dynamics underscore the extent to which climate change, as a socially contested issue, remains highly sensitive to political agendas and can directly shape both educational and research priorities.

Compared with Segade et al. [59], the findings highlight the difficulty of accessing secondary teachers as a research population, revealing a knowledge gap regarding these key actors who mediate between curricular and scientific knowledge and their students. Whereas Segade et al. [59] reviewed studies involving students from 36 national contexts, this review identified teacher-focused research in only 15 countries, with a ratio of 3:1 in favor of student-centered studies. Addressing this imbalance is therefore essential, as teachers' perspectives and evaluations of climate change as an educational topic are critical to developing effective, context-sensitive responses in schools.

The analysis of cited authors and institutions confirms the presence of internationally established reference points or schools of thought, while also highlighting differences with the Segade et al. [59] review. The prominence of Eric Plutzer, partly due to his highly cited 2016 study, contrasts with the absence of Edward Boyes and his team, long-standing leaders in research on climate change education with students. Other relevant figures include Maria Ojala [10], whose work reinforces the importance of emotional dimensions in educational responses to climate change. Influential institutions such as the IPCC, UNESCO, and the National Research Council also emerge as key sources shaping the field.

The main perspectives that guide research in this area focus on three thematic axes: climate change as a scientific object—both its understanding and its teaching; teacher beliefs, development, and training; and didactic innovation. These are complemented by emphases on environmental and scientific literacy, educational systems and contexts, emotional and cultural dimensions, and the promotion of student agency.

5.2. Methodological Approaches

Methodologically, the field is characterized by diversity in designs, techniques, and instruments. Compared with Segade et al. [59], this review reveals greater reliance on qualitative and mixed-methods studies with small samples, reinforcing the difficulty of recruiting teachers for research—unlike students, who often constitute a more accessible population.

At the same time, the uneven geographical distribution of research production, with a clear bias toward the global North, reflects the structural imbalances highlighted in the introduction. The relative invisibility of Latin American and Global South contributions illustrates how academic knowledge production continues to be mediated by neoliberal logics and global hierarchies that prioritize English-language publications from elite journals as discussed in Section 1 of this paper. Expanding research beyond these epistemic and geopolitical asymmetries remains an urgent task for the field.

5.3. Recommendations for Future Research

In sum, this review not only maps how climate change education has been addressed with secondary-school teachers—an underrepresented group in the literature despite its central role—but also identifies consolidated reference points and persistent gaps. Future research should expand geographically, including regions underrepresented in our sample. To this end, comparative studies may constitute a promising approach for placing different realities into perspective, enabling an examination of both divergences and convergences in how climate change is addressed within the field of education. In addition, future studies should diversify methodologically, including longitudinal designs to monitor the trends identified in this study, and integrate cognitive, emotional, and contextual dimensions both as analytical parameters and as means of achieving deeper interpretative insight. More importantly, research should move beyond climate literacy toward critical and transformative approaches that empower teachers as agents of educational and social change. Only by aligning research with these transformative goals can environmental education effectively address the systemic roots of the climate crisis and help build a more equitable and transformative field, as envisioned in the introduction to this study.

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Data Availability Statement: No supplementary datasets were generated or analyzed in this study. The data extracted from the reviewed studies are fully reported in Tables 1 and 2 of the manuscript.

Conflicts of Interest: The author declares that he has no conflicts of interest.

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