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Systematic Review

Empowering Secondary Education Teachers for Sustainable Climate Action

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Abstract: Climate change education plays an important role in sustainable climate action, but there is a lack of knowledge about how middle and high school teachers address it. This presents an opportunity to explore the research on these essential agents of education in promoting sustainable behaviors among adolescents. This study aims to systematically identify and analyze the existing scientific literature concerning the knowledge, perspectives, challenges, and opportunities of middle and high school teachers regarding climate change as an educational topic. The review protocol adheres to the PRISMA extension for scoping review statements. The methodology includes the establishment of eligibility criteria, consultation of Scopus and Web of Science databases, implementation of a search strategy based on a preliminary scoping exercise, and the utilization of the CADIMA online tool to facilitate the selection and data collection processes. This systematic process resulted in a sample of 41 studies, which were rigorously analyzed. Results suggest multiple factors that challenge how teachers address climate change in their classrooms. Curricular constraints, limited school time, controversy surrounding the phenomenon, and lack of training emerge as potential obstacles. However, these challenges also present opportunities to improve and promote sustainable climate action among young students.

Keywords: systematic review; environmental education; teachers; sustainable climate action

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1. Introduction

Climate change education (CCE) has emerged as a prominent research field in the educational arena over the last decade [1–3]. CCE focuses on how human-caused climate change (CC) has been incorporated into educational systems as a complex socioscientific issue posing a significant challenge for contemporary societies [4,5].

As a result of its increasing importance, CCE has led to the publication of several reviews aimed at synthesizing the emerging knowledge produced in recent years. Some of these reviews focus on issues related to students' knowledge, attitudes, perceptions, or behaviors [6,7]. Meanwhile, others aim to identify effective educational interventions and teaching practices [8,9] related to the professional development of CCE [10]. In addition, a scoping review was conducted on the sources of information from which teachers access information on CC [11]. Despite the growing interest in CCE, no reviews were found that specifically focused on secondary education teachers (both lower and upper secondary education) as the primary participants and in which CCE was the main educational topic. However, two existing reviews address similar topics and may help justify the need for the present review.

Firstly, Chen and Xiao [12] conducted a systematic review focusing on science teachers and their views on teaching socioscientific topics. Given that CC is a socioscientific topic that requires considering multiple relationships of elements from social science and natural science fields [4], their work is relevant to the purpose of the current study. The authors scanned the Web of Science, Education Resources Information Center (ERIC), and PsycINFO databases and identified 25 papers that fit within the scope of their review, but only one

research paper focused on CC. Hence, the expectation of the presented review is to provide an additional synthesis of knowledge distinct from that of Chen and Xiao [12].

Secondly, Nepraš et al. [13] conducted a literature review on CCE, identifying 43 articles published between 2001 and 2020 in the Web of Science database. Their review focused on studies targeting students and teachers at International Standard Classification of Education (ISCED) levels 1 and 2, which correspond to primary and lower secondary education. However, upper secondary and post-secondary non-tertiary teachers were excluded from their analysis, and only 6 out of the 43 articles focused on teachers. Therefore, the current study aims to build on the work of Nepraš et al. [13] by examining teachers' perspectives on CCE across all levels of secondary education and by including articles from the Scopus database.

Taking into consideration the aforementioned information, the objective of the current research is to investigate how middle and high school teachers approach CC in their daily work. By synthesizing this knowledge, the aim is to enhance the comprehension of the accomplishments and evolution of CCE from the teachers' perspective. The findings are anticipated to provide a synthesis of knowledge about teachers' perspectives on CCE that could be useful for curriculum creators, higher education institutions, and lifelong education stakeholders in integrating the climate crisis into middle and high schools. However, it is crucial to acknowledge that every literature review has its own limitations. Therefore, the review process has been elucidated in as much detail as possible to ensure transparency, replicability, and upgradability.

Below, a detailed report is provided on the steps taken in accordance with systematic scoping review recommendations [14,15].

2. Materials and Methods

The systematic review protocol followed in this study [16] adhered to the recommendations provided for conducting scoping reviews [15] (see Supplementary Materials [17]). To systematically conduct the protocol, the open-access web-based software tool CADIMA vers. 2.2.4.2. was utilized. This tool supports and guides through all the necessary steps for protocol implementation [18].

I look forward to answering the following research question:

What challenges and opportunities for promoting CCE among secondary education teachers emerged from the review?

Five inclusion/exclusion criteria were established to identify documents that fit the research interests. The first three criteria relate to the PIT question type [19], while the remaining two criteria pertain to the publication type and language limitations of the authors. The inclusion criteria are as follows:

1. The primary participants must be middle and high school teachers.
2. The documents must focus on CCE.
3. The results must be related to the comprehension of CC and educational interventions.
4. Only articles are considered for inclusion.
5. Documents must be written in English, Spanish, or Portuguese.

Web of Science and Scopus databases were utilized for the study search and identification process. The search was conducted on 23 February 2023. Additionally, the reference list of similar reviews previously mentioned was examined to identify any studies that might have been missed during the review.

The search strategy was designed to identify studies that involve middle and high school teachers as the primary participants, with a focus on ISCED levels 2, 3, and 4 (see details of the protocol [16]). The final search string is as follows:

(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*"))

Prior to selecting the studies stage, three rounds of consistency checks were conducted using CADIMA software and the Kappa index for abstracts. Forty-one records (10%)

were randomly selected for this check. Three reviewers, two external reviewers (see Acknowledgments section), and the author of the study independently screened each record. It took three rounds to define clear and consensus-based eligibility criteria that achieved an appropriate inter-reviewer agreement. After the second round, the results were discussed among the three reviewers to resolve any doubts or divergences in the results, and the criteria were redefined. The third consistency check showed excellent inter-reviewer agreement (K = 0.869).

3. Results

Figure 1 illustrates the flowchart that represents the search and selection process carried out in accordance with the previously established protocol, following the PRISMA statement for scoping reviews. The outcome of this process led to the identification of 41 studies that satisfied the eligibility criteria. The utilization of the CADIMA tool facilitated the sequential, documented, and systematic execution of the process, thereby assisting in document identification and content analysis.

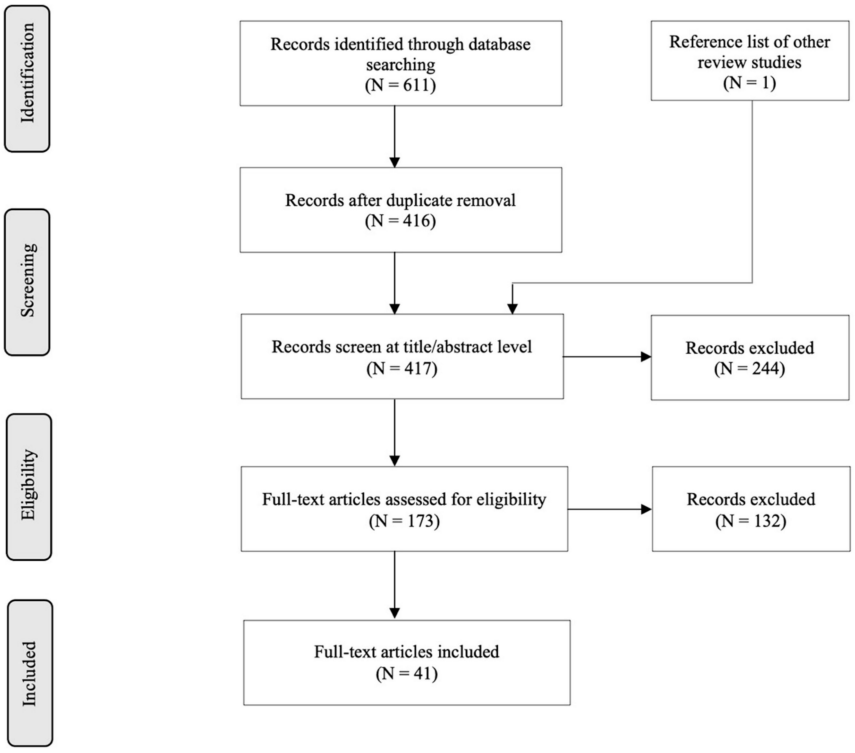

Figure 1. Selection process. Flow diagram in accordance with PRISMA-ScR [15].

Table 1 provides an overview of the gathered research. In 19 out of 41 of the studies, the participants consisted solely of science teachers, with two of them conducted among marine science teachers. In 14 out of 41, the participant sample included teachers from various disciplines. The remaining studies involved the participation of geography teachers in seven out of 41, and 1 study included agriculture teachers.

The research topics are diverse, encompassing various cognitive elements, experiences, and instructional practices. They also involve the implementation of strategies and activities to integrate CC into the classroom or curriculum.

Table 1. Thematic data extracted.

Study	Year	Teacher's Specialization	Educational Level	Topic (Based on the Aims and Research Questions Stated by the Authors)
[20]	2022	Geography teachers	Secondary School	Integration of CCE in classroom lessons
[21]	2022	Miscellaneous	High School *	Teachers' perceptions about CC
[22]	2022	Marine science	High School	Influence of personal beliefs teaching CC and the impact of political controversy on CC instruction
[23]	2022	Miscellaneous	High School	Teachers' viewpoints on CC and their willingness to include CC concerns in classes
[24]	2022	Miscellaneous	Secondary School	Teachers' climate science literacy and its influence on expressed training needs.
[25]	2022	science teachers	High School	Teaching CC and the implementation of epistemic activities for practice-oriented science instruction
[26]	2022	science teachers	Secondary School	Teachers' implementation of climate-focused curricular interventions
[27]	2021	Miscellaneous	Secondary School *	Views of teachers about CCE in the curriculum
[28]	2021	Marine science	High School	Teacher beliefs about CC
[29]	2021	Miscellaneous	High School	Emotions in teaching about CC and their handling/coaching of emotional reactions in the classroom
[30]	2021	Science teachers	Middle School	Perceptions of CC barriers and understanding of CC
[31]	2021	Science teachers	Secondary School	CC perceptions of secondary science teachers
[32]	2020	Miscellaneous	Lower Secondary	Teachers view CC at present and in the future and the practices that can be inserted into the school context
[33]	2020	Miscellaneous	Senior Secondary	Awareness of CC and willingness to adopt pro-environmental behavior
[34]	2020	Science teachers	Middle and High Schools	Time spent on CC in the classroom, use of a consensus-informed approach, and state-level curriculum standards
[35]	2020	Miscellaneous	Middle School	Teachers practices and emotions
[36]	2020	Agriculture teachers	Secondary Education	Teachers' knowledge, the choice of their practices, and their beliefs about GCC
[37]	2019	Science educators	Miscellaneous	Cultural values, worldviews, and support for the topic
[38]	2019	Science teachers	Secondary School *	Arguments in favor of and against CC denial theories
[39]	2018	Science teachers	Middle and High Schools	Teaching practices (time, emphasis, debates), content knowledge, and ideology regarding CC
[40]	2018	Miscellaneous	Secondary School	Gaps and differences between risk and perceived risk and effective and sustainable adaptation strategies.

Table 1. *Cont.*

Study	Year	Teacher's Specialization	Educational Level	Topic (Based on the Aims and Research Questions Stated by the Authors)
[41]	2018	Geography teachers	Lower Secondary	Teachers' beliefs and classroom practices when teaching weather formation and CC
[42]	2017	Miscellaneous	Lower Secondary	Knowledge, attitudes, and practices towards CCE
[43]	2017	Geography teachers	High School	CC science literacy (processes and causes of CC, CC impacts, CC responses)
[44]	2017	Science teachers	Middle School	Teachers' experiences and motivations in teaching CC
[45]	2017	Miscellaneous	Secondary School	Goals, knowledge, competencies, and values about CCE
[46]	2017	Miscellaneous	Secondary School	Perceptions of risk education
[47]	2017	Science teachers	Secondary School	CCE experiences, understanding of CC consensus and controversy, and specific practices
[48]	2016	Geography teachers	Lower Secondary	Emotions about the consequences of CC, strategies for coping with emotions, and views on CC mitigation
[49]	2016	Science teachers	Middle and High Schools	Aspects of teaching CC, knowledge, and beliefs
[50]	2016	Science teachers	Middle School *	Politically driven CC beliefs
[51]	2015	Miscellaneous	Secondary School *	Personal and professional beliefs about CC and CCE
[52]	2015	Science teachers	Secondary School	CC science knowledge
[53]	2015	Science teachers	Secondary School *	Social negotiation in the advancement of CCE (attitudes, opinions, and experiences)
[54]	2015	Geography teachers	High School	Literacy regarding CC science
[55]	2015	Geography teachers	Secondary School	Understandings of CCE
[56]	2014	Miscellaneous	Secondary School	CC topics included across disciplines, views of CC in the curriculum, and barriers and opportunities
[57]	2013	Science teachers	Secondary School	Willing to convey CC information, ability to address controversial topics, beliefs in policy, and economic
[58]	2013	Science teachers	Secondary School *	Background knowledge, need for cognition, need for closure, topic emotions, and plausibility perceptions
[59]	2010	Science teachers	Middle and High Schools	Views and practices of CC as controversial topics: Motivations and barriers
[60]	2002	Science teachers	Middle School	CC in the British science curriculum

Miscellaneous = various academic fields: Math, Foreign languages, Arts, History, Geography, etc.; CC = climate change; CCE = climate change education. * Mixed sample of teachers from different educational levels (pre-service teachers, elementary education, Higher Education Institutions, etc.) or students.

4. Discussion

4.1. Teachers' Understanding and Perspectives of Climate Change

The complexity of the climatic system poses a great challenge to its comprehension and definition by the general populace. While most teachers acknowledge the existence of CC [21,36,49,50] and appear to demonstrate a higher degree of expertise on the subject compared to the general population, they also grapple with comprehension hurdles [20,38,49,51].

Varying levels of knowledge regarding CC are observed within the teacher cohorts themselves, with instances where the sample is nearly evenly divided, with approximately 50% exhibiting moderate-low levels of understanding and the remainder demonstrating moderate-high levels of comprehension [42,53]. It is noteworthy that factors such as age, teaching experience, and specialized training exert influence on levels of climate science knowledge [23,39,42,43].

The challenge of comprehending the climatic system appears to persist even among teachers specializing in science or geography, disciplines wherein CC typically features as obligatory content. Principal challenges are identified in connection with general knowledge of climate science and with the scientific consensus surrounding its anthropogenic causation [22,24,30,31,42,47,49–53,55,59]. With respect to the scientific consensus on the causes of human-induced CC, Sezen-Barrie and colleagues concluded that teachers might still doubt the anthropogenic causes of climate change when teachers (a) do not have a comprehensive understanding of sea ice vs. land ice, functions of the ecosystem, solar cycles, and weather vs. climate; (b) rely on a single source; or (c) lack understanding of how climate data are collected and validated in models [38] (p. 16).

In the case of teachers who struggle with comprehension, definitions of CC often focus on isolated aspects of the phenomenon, such as rising temperatures, temporal aspects, or meteorological changes. This skewed understanding, primarily in its atmospheric and meteorological dimension, fails to consider the reality of a complex system and the numerous aspects, relationships, and feedback loops that should be part of a scientifically accurate representation of the phenomenon. At other times, these representations contain misconceptions commonly shared by the general population [31,49,52,55,59]. Tautologies or denialist arguments are used to a lesser extent to define it [38,52].

Regarding knowledge of the causes, consequences, and solutions of CC, teachers appear to follow the trend observed in other research involving secondary education students as the target population. Consequently, it seems that teachers possess a stronger grasp of the processes and underlying causes of CC compared to their comprehension of its social, economic, and health repercussions, as well as potential solutions [42,53].

Concerning their knowledge of the causes, inconsistencies arise in their perspectives. Despite a great percentage of teachers confirming their agreement regarding the existence of a scientific consensus on CC causes, they harbor doubts about the nature of these causes [27,28,30,38,49]. These doubts stem from beliefs that the evidence surrounding the phenomenon is weak or flawed, that the employed methods lack reliability, or that natural forces are significant contributors to the ongoing CC [31,36,38,42,47,50,59].

Regarding solutions, teachers attribute responsibility for mitigation actions to individuals and politicians, with politicians bearing a greater burden due to their decision-making power. Additionally, economic powers are also identified as primary agents responsible for implementing mitigation policies and actions [48]. However, in the case of a unique Brazilian study, teachers do not perceive themselves as part of the solution due to the devaluation of the teaching profession in their country [32].

Furthermore, Hermans [48] analyzes the discourse of Finnish teachers and identifies two categories related to mitigation strategies. On the one hand, there are contextual strategies such as the development of climate-friendly technology, the implementation of carrot-and-stick policies, and international agreements. On the other hand, motivational strategies emerge around the relationship between knowledge, attitude, and behavior. When discussing mitigation measures at the personal level, they propose two types of

actions: those with direct impact aimed at addressing the problem and those with indirect impact intended to influence others to participate in the solution. Among direct actions, teachers suggest actions that do not require a personal sacrifice of their lifestyles (e.g., recycling, turning off lights, etc.), although some also question the impact of their lifestyles and accept other actions, such as reducing shower time or using their cars less. Finally, indirect actions are directly related to their work time through teaching [28]. These actions are further reinforced by various types of motivation, including being a role model, a sense of personal responsibility, or considerations related to health and personal finances.

Despite secondary education teachers asserting a stronger grasp of CC knowledge compared to the general population, they also hold misconceptions about the phenomenon [31,32,36]. A significant portion of teachers tends to accept the existence of at least two valid explanations for the causes of CC: natural cycles and human activities [22,36]. This perception contrasts with the scientific reality of the phenomenon [4], and as Nicholls and Stevenson indicate this representation "does not present a realistic picture or understanding of CC" [51] (p. 26). The natural greenhouse effect, its alteration by human activities, or misunderstandings regarding the ozone layer and its depletion further contribute to the confusion surrounding the understanding of CC and are found in a small subset of the teaching staff [31,42,49,52,55,59].

Regarding the emotions triggered by the CC, teachers identify feelings of concern, anger, fear, guilt, or hopelessness when contemplating the consequences of the CC [28,48]. But there are also some teachers who express hopefulness in dealing with CC in school, even though they are not in the majority [38]. The concern, rated as moderate, is projected toward the future, nature, or the upcoming generations, suggesting that they do not perceive CC as a current issue that may personally affect them. However, they simultaneously hold a negative representation of the present and future state of the planet [32]. Their anger is directed at major institutions, corporations, nations, or the political establishment, attributing primary responsibility for the CC to factors beyond their day-to-day control. Additionally, emotions play a significant role in shaping perceptions of the plausibility of CC. Hopelessness appears to be positively correlated with such perceptions, whereas anger shows a negative correlation.

Factors such as motivation and gender also play a role in shaping the emotions elicited by CC. For instance, among teachers who are motivated by the subject, "teaching about climate change provides important psychological benefits for them. It brings them joy and gives them hope for the future" [44] (p. 18), while women tend to express heightened concern about the issue [29].

Finally, Anyanwu and Le Grange [43] conclude that male geography teachers achieve higher knowledge scores compared to their female counterparts, a trend also identified in another study [42]. Although these findings are consistent with other research involving student populations, it is important to note that these studies are limited to the Western Cape Province in South Africa and Tehran, Iran. As the same authors acknowledge, confirming these results would require larger sample studies involving teachers from diverse countries and specializations.

4.2. Teaching Climate Change in Secondary Education

The strategies employed to teach it vary, ranging from using textbooks, internet resources, epistemic practices, or lectures to practical assignments, laboratory experiments, or debates, among other approaches. These preferences appear to be more influenced by personal choices than professional ones, often stemming from past experiences, worldviews, classroom dynamics, the subject being taught, the socioeconomic and personal backgrounds of the students, as well as physical and curricular constraints. Similarly, there is a divergence of opinions regarding which discipline should take on the responsibility for its educational integration [26,34,36–38,40,41,45,55,59]. The divergence of opinions and perspectives within these communities must be taken into account while also considering internal social divisions, since, as Walshe and colleagues indicate:

While there is a general agreement that climate change is a human-induced problem and a threat to society, it is clear that there is considerable intergroup and country diversity in perceptions of climate change. This diversity is problematic to integrate into the top–down policy-led interventions, particularly those that are multi-national in scale [40] (p. 315).

Moreover, the complexity and controversy surrounding the phenomenon lead to a situation where, although a portion of teachers in science-related disciplines declare feeling comfortable teaching CC, 14% express discomfort [57]. These percentages increase to 40–60% among teachers in other disciplines related to social sciences, humanities, economics, and mathematics [56].

The teaching of CC often focuses on its causes and consequences, primarily from exclusive perspectives of the natural sciences [21,25,29,36,44,45,49,51]. Although in some cases, teachers emphasize that "[CCE] includes social justice and participation in social action as part of the school curriculum" [27] (p. 1675), there is generally limited exploration of the social and economic causes and consequences. Two distinct perspectives emerged that differentiate how science teachers and agricultural teachers approach the content of CC [56]. Science teachers base their strategies on imparting the scientific principles that underlie the causes of climate change, while teachers in agricultural science and technology concentrate on the impacts and adaptation measures. On the other hand, business teachers argue that it is unnecessary to grasp the basic principles of climate science, leading them to incorporate CC primarily through the lens of economic impacts stemming from various extreme events. Despite teachers expressing an interest in integrating CC into their teaching practice, the time invested is limited due to various factors such as curriculum constraints, lack of knowledge, and the difficulty of aligning CC content with teaching standards, among others [34,36,49,56].

The potential and most effective solutions, both at the individual and collective levels, also appear to have a limited role in CCE. When they are addressed, the focus tends to be on technological solutions and environmentally friendly actions, often overlooking political solutions. Understanding the importance of political solutions is crucial for gaining acceptance among the broader population [31]. This curricular perspective, which confines the learning of CC to specific natural science disciplines, does not go unnoticed. Some authors argue that modern education often neglects postmodernist ideas and a diversity of perspectives [60]. This deficiency is reflected in most teaching practices, which do not actively seek to or successfully cultivate the critical thinking skills necessary for evaluating controversial situations. In this sense, science and geography teachers express the difficulty of proposing strategies and methodologies that foster students' interest in participating, discussing, and arguing—skills that are developed in other social science subjects more closely connected to their social reality [45]. Furthermore, they emphasize working on climate-related content if it allows them to achieve other overarching objectives such as [27,45,51,55,57,60]:

- Fostering responsible and informed decision-making.
- Grasping the boundaries of science and the dynamic process of constructing scientific knowledge, grounding in evidence, and responsive to environmental and social challenges.
- Cultivating critical awareness of social inequality and injustice.
- Acknowledging the existence of intricate, global-local relationships.
- Establishing connections between science and everyday life.
- Nurturing the ability to discuss and negotiate in pursuit of solutions to complex and contentious socioscientific.
- Developing civic competence.

When it comes to discussing the climate topic in class, there are different opinions on how to include it and in what context, whether formal or informal [59]. Moreover, although educational curricula are typically centralized and prescriptive, the way CC is addressed in the classroom varies depending on the teachers [55], with political orientation

and worldviews being one of the influencing factors that could impact the teaching of CC in public schools in the US [31,37].

Among the teachers who report using specific strategies to address the topic, they highlight those related to the nature of science, involving students in data collection, analysis, and conclusion formulation [57]. Other strategies they mention include explaining scientific uncertainty, presenting the reasoning behind different interpretations of CC, discussing the pros and cons of climate-related policies [48], exploring the history of CC science, engaging in discussions about skeptical beliefs [59], spatial and temporal reasoning [38], and planning or constructing evidence-based explanations [44].

Plutzer and colleagues found out that "teachers who teach CC, 31% report sending explicitly contradictory messages, emphasizing both the scientific consensus that recent global warming is due to human activity and that many scientists believe recent increases in temperature are due to natural causes" [49] (p. 664). In this regard, various viewpoints exist regarding the proposal to present different perspectives on the origins of CC causes, with some teachers deeming it appropriate and others not [31,39,51,55,57,59]. In this scenario, the conflict emerges between teachers who advocate introducing students to the two primary arguments that explain the causes of the phenomenon, human vs. natural, and those who endorse the argument grounded in the scientific consensus established by the IPCC, attributing the disruption of the climate system to human activities. Wang and colleagues [36] identified this perspective among most of their participants, while Nicholls and Stevenson observed that a small subset of teachers in their sample asserted that CC is "fictitious, a politically motivated topic or biased toward a political agenda, an unsupported idea driven by media, the result of unscrupulous scientists lying for money, the unsupported popular beliefs of ignorant people, or a combination of these points" [51] (p. 25). Furthermore, this perspective may influence teaching practices, as teachers from states with standards emphasizing both sides were less inclined to adopt a consensus-informed approach to instruction [34].

Closely related to this, ideology is also a factor that influences how the topic is taught, with teachers who "display a small government ideology are more likely to encourage debate and less likely to emphasize the scientific consensus" [39] (p. 9). The public controversy surrounding the phenomenon leads teachers to maintain neutrality when addressing the topic in the classroom and to avoid engaging in argumentative debates [22,28]. In connection with this, Plutzer and Hannah [39] highlight the risk of using debates in which there are two valid narratives, potentially causing confusion among students about the scientific reality of CC.

The risks associated with CC are another area of interest in CCE among teachers. Some teachers highlighted the need to address more risk-related topics in schools [46]. They also recognized that the primary risks their students will face in the future will have a socioeconomic nature. However, their teaching practices predominantly revolve around environmental threats, often without linking them to their social and economic implications. The authors explain that this is due to the materials used in classrooms being dictated by the school curriculum, which outlines mandatory content, and unfortunately, the social and economic impacts are often omitted.

In island contexts, where the threats of CC are more visibly manifested through rising sea levels and extreme weather events, teachers frequently stress the importance of the topic as a relevant educational subject that should be contextualized to address local concerns and engage the public in the climate crisis [36,40]. However, other studies indicate that teachers often fail to establish these connections with the local consequences of their environments in their teaching practices [22].

The risks and threats of CC generally evoke negative emotions related to concern, anger, guilt, or hopelessness [28,32,38,48], which can have an impact on educational practices. However, when the focus shifts to the emotions of their students, opinions vary. Some teachers perceive their students' negative emotions as irrational and disapprove of addressing them in the classroom, while others consider concern or hopelessness as

rational, coherent, and reality-oriented emotions. At the same time, they view hope as a catalyst for teaching and learning processes. Other emotions like anger, frustration, or irritation are identified as promoters of learning because they enable active responses to disruptive stimuli [29]. This diversity of opinions allows us to identify four strategies that teachers use to manage emotions in the classroom: "avoiding negative emotional reactions, action-based and reappraisal-based coaching, strategies to approach negative emotions, and an uncommon flexibility and adjustment coaching strategy" [29] (p. 48).

4.3. Climate Change as an Educational Issue

CC as an educational topic has been incorporated into curricula as compulsory content in various countries for quite some time. Then, most teachers express their support for its inclusion in school education, along with potential individual and collective solutions [23,36,40,44,47]; nevertheless, worldviews seem to be an influential factor in supporting its curricular inclusion. Those teachers who adhere to a hierarchical and individualistic worldview "reported stronger beliefs that EC [egalitarian-communitarian] concepts should not be taught" [37] (p. 10).

Some also highlight the interdisciplinary nature of this topic and its integration across various disciplines through a cross-curricular approach [27]. However, most indicate its incorporation primarily within scientific disciplines such as Geography or Earth Sciences, and there are significant percentages indicating the marginalization of this content, either by confining it to informal settings or by avoiding it altogether [36,59]. It is worth noting that in one study, teachers did not express declarations related to the extent to which education could have a co-responsible role in mitigating CC, indicating that CCE is not perceived as a mitigation strategy [48].

Within their respective disciplines, there are similarities in identifying links, or the lack thereof, between CC and their own content and curriculum standards. However, differences exist among disciplines. While teachers in scientific disciplines tend to identify more opportunities to incorporate CC into their educational practices, those in social and human sciences do not find as many connections with their content [23,27,36,44,56,59]. In some cases, specific curricula may include CC in subjects like geography [55], or it may be regarded as cross-cutting content from the perspective of environmental education [42].

The complex nature of CC and its connections to human societies result in varying perspectives among the authors regarding its curricular integration. The majority agree on identifying CC as a socioscientific [23,25,60] and controversial topic [31,34,39,44,47,51,54,55,57–59]. Therefore, it seems that CC transcends its purely scientific dimension, encompassing other facets such as social, political, economic, environmental, cultural, ethical, and media-related aspects. This presents a challenge for most secondary school teachers. The public and media controversy, which is not scientific in nature, particularly concerning the anthropogenic causes of CC, could impact the content of CCE and its promotion in classrooms, potentially leading to students questioning the validity of the science behind the phenomenon [47,49,59].

In relation to this, there appear to be different positions among teachers regarding how they address this controversial issue: some advocate presenting all viewpoints and explanations on the causes of CC as valid, while others present both views with uncertainties and doubts. There is another contrasting trend: some declare that their responsibility is solely to teach the natural causes of CC in relation to those who adhere to a hierarchical and individualistic worldview [37], while others argue that the only valid position is that provided by the scientific community, as long as it begins with an acknowledgment of the inherent epistemic uncertainty in the construction of scientific knowledge [44,47,57,59]. However, a majority supports teaching 'both sides' of the phenomenon and asserts that they do so with the aim of promoting independent and critical decision-making, thereby allowing them to teach about the nature of science [47].

5. Conclusions

To conclude, with the aim of promoting sustainable climate action among secondary education teachers and their students, I present a compilation of challenges and opportunities to reflect upon the goals of CCE in achieving this objective.

5.1. Challenges in Promoting Sustainable Climate Action in Secondary Education

Curriculum limitations. The content knowledge either does not align with the curriculum standards or is pre-determined and confined to specific subjects such as Geography or Earth Sciences [36,40,42,47,56,57,59]. This restricts the level of discussion, participation, and argumentation required to address complex and controversial social and political issues, in contrast to other disciplines within the social sciences that allow for such depth of engagement due to their own methodologies and content [45]. Additionally, the curriculum standards are influenced by the climate culture and policies of different states [31]. Moreover, many students are unable to access this knowledge because they are pursuing different academic pathways [23,34]. Furthermore, the treatment of CC as a closed topic within curricula and textbooks that prescribe both the form and content to be covered makes it challenging to contextualize the issue within local contexts [30,39,45,55].

Understanding limitations and personal influence. A lack of knowledge about the subject can result in teachers feeling uncomfortable or having low levels of enthusiasm regarding the topic [24,27,31,40–42,54–56,59]. This, in turn, necessitates the reliance on textbooks for structured and well-defined guidance in their classroom treatment [45,55]. Conversely, ideological conflicts related to CC, political affiliations, personal or religious beliefs, and attitudes also play a significant role in shaping the implementation of CC content [22,31,34,36,47]. In states or countries characterized by heightened political polarization and widespread CC denial, environmental education encounters obstacles that originate in political decision-making bodies and extend to pressures placed on teachers by family members, colleagues, or students, urging them to avoid its inclusion in school curricula [47,49,54].

Time Constraints in Schools. These limitations impact both how it is addressed in the classroom and the ability to participate in ongoing professional development activities related to the subject [30,41,56].

Lack of Funding and State Support. International organizations, agreements, and reports emphasize the significance of education as a critical component in addressing the climate challenge. While these guidelines and recommendations for an action plan have encouraged the integration of the climate emergency into state educational policies, it is important to note that legislative inclusion alone does not guarantee the effective execution of new educational initiatives. Adequate funding is essential for teacher training, network establishment, and the provision of schools with the necessary materials and resources [30,54].

Elevated Levels of Public Controversy. Social and politically contentious subjects can result in self-censorship among teachers, leading them to avoid discussing these topics in the classroom or presenting them as scientifically controversial rather than socially or media controversial. Political ideology and worldviews seem to be the more powerful predictors of teachers' classroom approach than any educational aspect [37,50]. This situation is also exemplified by the topic of 'evolution' in certain states within the USA [22,27,47,55].

Emotions Associated with the Topic. CC elicits emotions such as hopelessness or concern that can result in reluctance to discuss the consequences of the phenomenon in the classroom, downplaying them within a local context or perpetuating a negative emotional perception among students, potentially fostering disengagement with the issue [48,58].

Underestimation of the Educational Potential. CCE is not widely regarded as a mitigation strategy for CC among education professionals, while some teachers do not see themselves as contributors to the solution due to the undervaluation of the teaching profession in their country. Additionally, there is a lack of significance and interest on the

part of students who fail to recognize the connections between the phenomenon and their daily lives [32,41,48].

Insufficient Teacher Training. Both at the start and during ongoing in-service and pre-service teacher instruction and training [31,39,40,49]. Furthermore, a high self-perceived level of knowledge about CC among skeptical adults reinforces their beliefs and serves as a barrier to their participation in teacher training activities. Additionally, teachers who express more discomfort with the topic are the least interested in professional development related to the subject [24,30,48,56].

5.2. Opportunities to Promote Sustainable Climate Action in Secondary Education

Despite the existing barriers, experiences that inspire the inclusion of CC in classrooms have a more significant impact on teachers than those that discourage them.

Integration of Curriculum Climate Change Content. The extent to which CC is part of curriculum contents influences the amount of class time devoted to addressing the phenomenon [34,36]. This suggests that an expansion of curriculum CC content will result in a stronger focus on the topic in the classroom. Additionally, CC is a subject that enables and necessitates the development of critical thinking skills, problem-solving abilities, and an understanding of the functioning of the political system [51]. These interdisciplinary and transdisciplinary skills can facilitate its integration into the curricula of various secondary education subjects, fostering synergy and added value among different methodologies for teaching natural sciences and social sciences. In addition, the multifaceted nature of CC allows for its inclusion in any subject within the secondary education curriculum [45]. Moreover, aside from textbooks, there is a wealth of primary sources, empirical data, and materials related to CC that can be utilized in the classroom [49,55]. However, these resources require clear instructional guidance for effective implementation within the classroom setting [26].

The Expertise of Environmental Education. Despite the potential challenges that may arise from an administration holding denialist positions, the extensive history of environmental education and its expertise in addressing controversial socioscientific issues enable the coordination of stakeholders and material resources (textbooks, media, etc.) as mediating actants for negotiating CC in the secondary science classroom [38,54].

Problem-Focused and Solution-Oriented Strategies. These strategies have proven to be effective for coping with the emotions generated by CC. In contrast to emotion-focused strategies that downplay, deny, or avoid the threat, these approaches seem to promote pro-environmental behaviors among students. Community-based workshops are also seen as a good strategy to combat student disinterest in the subject [40,48].

The Present Risk to Society. The uncertainty and threats posed by CC provide opportunities to contextualize and infuse CCE with significance, considering its social and environmental impacts. This perspective helps students become actively engaged in decision-making and the implementation of solutions. There is evidence regarding leisure time spent in natural settings and the diverse actions taken by teachers and students to mitigate CC [46,48].

Motivation and Collaboration. Committed teachers are an essential component within an educational institution. Encouraging optimism and sharing their experiences within their educational communities can have a profound impact on inspiring undecided teachers. Consequently, it is essential to propose collaborative projects and training activities involving both motivated and undecided teachers [25,28,44,59]. To accomplish this, it is crucial to provide teachers and students with the space and time to articulate their concerns in words and engage in discussions before addressing potential solutions to the problem.

Teacher Training and Professional Development. Teacher training is one of the most frequently mentioned topics in the studies, as teachers express the need for greater and better knowledge about CC, which can facilitate the adoption of teacher training proposals. Additionally, formal courses on the topic appear to have a positive influence on the amount of time devoted to addressing it in the classroom. Future professional development on

CC should include a variety of content knowledge related to climate science and its social dimensions, such as political, economic, and health issues, as well as local mitigation and adaptation strategies.

In this regard, higher education institutions and curriculum creators play a fundamental role in the training of future education professionals, although this is not sufficient and should be reinforced with training and professional development programs, networks, and lifelong education programs [20,22,49]. The public controversy surrounding CC is a topic of interest among teachers and can serve as a starting point for proposing training activities that allow for the refutation of weak, skeptical arguments. Confidence in scientific consensus is a predictor that positively influences motivation to teach CC in the classroom, so teacher training should strengthen the scientific reality of the CC alongside promoting a systemic view of the phenomenon, considering all its dimensions: scientific, social, cultural, health, economic, or ethical [25,31,44].

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