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Secção 1: *Investigação em Educação em Ciências, Matemática e Tecnologia*

CLIMATE CHANGE AS A SOCIO-SCIENTIFIC ISSUE IN SCIENCE EDUCATION - A SYSTEMATIC REVIEW

AS ALTERAÇÕES CLIMÁTICAS COMO UMA QUESTÃO SOCIOCIENTÍFICA NO ENSINO DAS CIÊNCIAS - UMA REVISÃO SISTEMÁTICA

EL CAMBIO CLIMÁTICO COMO CUESTIÓN SOCIOCIENTÍFICA EN LA ENSEÑANZA DE LAS CIENCIAS - UNA REVISIÓN SISTEMÁTICA

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ABSTRACT | This paper explores the integration of climate change (CC) as a socioscientific issue (SSI) in education, highlighting its role in enhancing scientific literacy and informed decision-making. A review of literature published during the last five years was conducted, and 17 articles of interest were identified. It appeared that combinations of SSI with other pedagogical frameworks, such as STEAM or problem-based learning, and with modern digital tools, have been attempted. Teaching CC as a SSI was shown to improve students' argumentation skill, and the importance of ethical reasoning and environmental awareness in addressing CC was noted. However, challenges remain, such as providing teachers with sufficient training for including CC as SSI in their teaching practices. Ultimately, teaching CC as an SSI equips students with the necessary skills to address the complex environmental challenges of the 21st century, and therefore should be introduced in an institutionalized manner in the curricula.
KEYWORDS: Socioscientific issues, Climate change, Pedagogical frameworks, Scientific literacy, Environmental literacy.

RESUMO | Este artigo explora a integração das alterações climáticas (AC) como uma questão sociocientífica (QS) na educação, destacando o seu papel no reforço da literacia científica e da tomada de decisões informadas. Foi efectuada uma revisão da literatura publicada durante os últimos cinco anos, tendo sido identificados 17 artigos de interesse. Verificou-se que foram tentadas combinações de QS com outros quadros pedagógicos, como o STEAM ou a aprendizagem baseada em problemas, e com ferramentas digitais modernas. O ensino da AC como QS demonstrou melhorar a capacidade de argumentação dos alunos, tendo sido registada a importância do raciocínio ético e da consciência ambiental na abordagem das AC. No entanto, continuam a existir desafios, como o de proporcionar aos professores formação suficiente para incluir a AC como QS nas suas práticas de ensino. Em última análise, o ensino da AC como uma QS dota os alunos das competências necessárias para enfrentar os complexos desafios ambientais do século XXI, pelo que deve ser introduzido de forma institucionalizada nos currículos.
PALAVRAS-CHAVE: Questões sociocientíficas, Alterações climáticas, Quadros pedagógicos, Literacia científica, Literacia ambiental.

RESUMEN | Este artículo explora la integración del cambio climático (CC) como una cuestión sociocientífica (CS) en la educación, destacando su papel en la mejora de la alfabetización científica y la toma de decisiones informada. Se realizó una revisión de la bibliografía publicada en los últimos cinco años y se identificaron 17 artículos de interés. Se observó que se han intentado combinaciones de CS con otros marcos pedagógicos, como STEAM o el aprendizaje basado en problemas, y con herramientas digitales modernas. Se demostró que la enseñanza del CC como CS mejora la capacidad de argumentación de los estudiantes, y se señaló la importancia del razonamiento ético y de la conciencia medioambiental a la hora de abordar el CC. Sin embargo, sigue habiendo retos, como proporcionar a los profesores la formación suficiente para incluir el CC como CS en sus prácticas docentes. En última instancia, la enseñanza del CC como CS dota a los estudiantes de las habilidades necesarias para abordar los complejos retos medioambientales del siglo XXI, por lo que debería introducirse de forma institucionalizada en los planes de estudio.
PALABRAS CLAVE: Cuestiones sociocientíficas, Cambio climático, Marcos pedagógicos, Alfabetización científica, Alfabetización medioambiental.

1. INTRODUCTION

The integration of socioscientific issues (SSIs) into education, particularly science education, has gained traction as an effective approach to developing students' critical thinking, problem-solving, and decision-making skills (Zeidler & Nichols, 2009). In other words, it contributes to scientific literacy beyond Vision I (Roberts, 2007), i.e. the simple acquisition of knowledge about scientific concepts, phenomena and processes, giving room for expansion to Vision II and III which means knowledge applied to everyday life, critical citizenship and scientific "knowing-in-action" (Aikenhead, 2007). Climate change (CC), as a pressing global issue, serves as a powerful SSI that can enhance scientific literacy and foster active citizenship. This review examines recent literature on the incorporation of CC into educational settings, highlighting its benefits, challenges, and pedagogical strategies.

CC education is essential for preparing students to navigate and address the complex environmental challenges of the 21st century. According to Stevenson et al. (2017), integrating CC into the curriculum helps students understand the scientific principles underlying climate phenomena and the socio-economic impacts of climate-related issues. Moreover, it promotes awareness and responsibility, encouraging students to engage in sustainable practices and informed decision-making.

Moreover, research has shown that there are several benefits of using CC as an SSI in education: Zeidler and Nichols (2009) argue that addressing CC through SSIs enhances students' understanding of scientific concepts and processes, making them more scientifically literate. According to Sadler et al. (2011), discussing CC encourages students to evaluate evidence, consider multiple perspectives, and develop well-reasoned arguments. Education on CC also fosters a sense of responsibility and empowers students to participate in civic activities aimed at mitigating climate impacts (Wodika & Middleton, 2020).

Several pedagogical strategies have been identified for effectively teaching CC as an SSI: Ratinen (2021) highlights the use of inquiry-based learning to engage students in investigating climate-related questions, conducting experiments, and analysing data. Engaging students in debates and argumentation helps them articulate their views on climate issues and understand opposing viewpoints (Sadler, 2004). In addition, the affordances of digital tools, such as simulations and interactive platforms, in enhancing students' understanding of CC and its impacts have currently been discussed (Becker & Jacobsen, 2020).

Despite its benefits, integrating CC into education has been found to pose several challenges: CC is often a controversial topic, and students may hold misconceptions or be influenced by misinformation (Lombardi et al., 2021). In addition, many teachers do not feel adequately prepared to teach CC due to their lack of content knowledge or pedagogical skills as well. Finally, the rigid structure of some curricula may limit opportunities to incorporate SSIs (author, 2016, 2024; author, 2013) like CC into the classroom (Evagorou & Nielsen, 2020). Over the past five years, the frequency and intensity of extreme weather events have significantly increased, serving as tangible evidence of the accelerating impacts of climate change. From unprecedented heatwaves and devastating floods to record-breaking hurricanes and historic droughts, the world is undergoing a climate transformation that can no longer be ignored.

In 2025, South Korea experienced its most destructive wildfires in 25 years, resulting in 32 deaths and the destruction of thousands of buildings. Analysis by Climate Central confirmed that climate change had doubled the likelihood and increased the intensity of such fires (Reuters, 2025). Similarly, during the 2019–2020 season, Australia faced the "Black

Summer" fires that burned over 18 million hectares, killed 33 people, and led to the death or displacement of billions of animals (Herald Sun, 2023).

In 2024, extreme rainfall in Brazil's Rio Grande do Sul state caused deadly floods that killed at least 55 people and displaced more than 70,000 (BBC News, 2024). That same year, floods in India resulted in 1,878 deaths and major disruptions to everyday life and agriculture (The Times of India, 2024).

During April 2025, India and Pakistan endured temperatures exceeding 50°C, with severe shortages of drinking water and electricity (The Guardian, 2025). In Japan, the 2024 heatwaves caused hundreds of thousands of cases of heatstroke, with record-breaking temperatures reaching 49.9°C (The Guardian, 2025).

Tropical storms have also intensified. In July 2024, Hurricane Beryl became the first Category 5 hurricane ever recorded that month, with wind speeds surpassing 280 km/h (NOAA, 2024). Meanwhile, in the United States, Hurricanes Helene and Milton in 2024 caused damages exceeding 50 billion dollars (Climate Adaptation Platform, 2024).

Drought conditions have also worsened. In 2025, the Himalayas recorded the lowest snowfall in 23 years, threatening water supplies for nearly two billion people in Asia (Nature, 2025). Additionally, El Niño-induced drought affected countries in Africa such as Zambia, Malawi, and Zimbabwe, leading to severe food insecurity (WMO, 2024).

Lastly, ecosystem disruptions have become increasingly evident. A 2025 study on the Arctic revealed significant shifts in vegetation due to rising temperatures, with profound consequences for local communities and wildlife (The Guardian, 2025).

These examples highlight the growing severity of climate-related events worldwide. The scientific community agrees that this is a worsening trend affecting every continent and sector of life. Therefore, the integration of climate education in the school context and with appropriate pedagogical approaches, such as SSIs, are necessary and can potentially contribute to the formation of informed and engaged citizens capable of understanding and responding to the climate challenges of the 21st century.

Based on the points outlined above, this study aims to answer the following research question:

- How has climate change been used as a socioscientific issue in educational research for the last 5 years?

2. LITERATURE REVIEW

The role of moral reasoning in SSIs and their introduction to scientific education was first discussed in 2004 by Sadler and Zeidler. Since then, teaching SSIs has evolved beyond the traditional Science, Technology, and Society (STS) framework, empowering students to examine the ethical dimensions of science, thus moving away from sterile scientific knowledge. SSI education delves into the moral principles and virtues in scientific decisions and their relevance to students' lives (Zeidler et al., 2005).

In recent years, the scientific and educational communities have been increasingly focused on environmental education and the scientific literacy of students, as these are essential for their future as skeptical citizens with scientifically and ethically informed thinking (Sjöblom, 2023). This issue, although not new, seems to be gaining significant attention today due to the serious social problems that have arisen, such as the extreme weather changes (Herald Sun, 2023; BBC News, 2024; Climate Adaptation Platform, 2024; WMO, 2024). SSIs are controversial social issues related to science, which do not have a single solution and require the examination of multiple factors (ethical, moral, cultural, traditional, economic, political, environmental), as well as scientific understanding and social consensus for their resolution (Sadler & Zeidler, 2004). It is crucial that the reasons behind a series of arguments which lead to the most appropriate solution must be justified (Georgiou et al. 2020a, 2020b).

The UN's Sustainable Development Goals (SDGs) aim to address challenges like CC, guiding nations towards a sustainable future by 2030 United Nations, n.d.). SSIs are instrumental in integrating SDGs into education through environmental literacy, crucial for achieving these goals. The alignment of SSIs with the SDGs lies in their shared focus on interdisciplinary approaches to complex global issues. SSIs and the SDGs emphasize informed decision-making, critical thinking, and responsible citizenship for sustainability and the improvement of society. The combination of scientific knowledge and social values and norms characterizes both, with the aim of sustainable, just solutions. These outcomes are applicable at local, societal, and global levels (Chowdhury et al, 2020).

Education (formal, non-formal, informal) plays a vital role in this. The introduction of CC into the educational curriculum of schools at all levels, as well as into many museums or other institutions, can contribute to the development of healthy environmental behaviour in students and a substantial understanding of climate-related issues (Tibola da Rocha et al., 2020). Approaching it also from the perspective of SSIs, students learn to utilize scientific data and consider all perspectives before arriving at a solution. Indeed, individuals who are willing to act and capable of making informed decisions represent the most critical prerequisites for a sustainable future (Sjöblom et al., 2023).

SSIs with topics as CC (and renewable energy) have been found to offer many benefits to students: they promote critical thinking, ethical decision-making, and the development of scientific literacy, raising awareness and shaping attitudes perceptions, values, and beliefs (Sadler & Zeidler, 2004; Lee & Grace, 2010). Those SSIs strengthen social engagement as students connect with broader global issues, aiding in understanding concepts and fostering responsible citizenship, ultimately leading to the development of informed individuals, critical for a sustainable future (Sjöblom et al., 2023).

Answering the research questions mentioned in detail above, this review covers various aspects of using CC as an SSI in education, drawing on recent literature to highlight its importance, benefits, pedagogical strategies, and challenges.

3. METHODOLOGY

For purposes of this study, a review of the literature relating to the subject was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021) and includes a systematic literature review (SLR) through Google Scholar. Using the PRISMA method is highly recommended when conducting a systematic review, as it ensures transparency, rigor, and replicability throughout the review process. Compared to other frameworks, PRISMA provides a clear and standardized structure for identifying, screening, and including studies (Tricco et al., 2018), and it is widely endorsed by the scientific community for its methodological robustness. The selection of Google Scholar as the primary database for this systematic review was based on its broader coverage compared to other platforms such as Scopus or Web of Science. Given the narrow timeframe targeted by the review, our priority was to retrieve every potentially relevant publication. All identified records were subsequently screened and evaluated for eligibility in accordance with the PRISMA protocol.

In order to answer our research question, the main search terms used were "socioscientific issue (SSI)" and "climate change". To avoid restriction of the results, instead of using the terms "socioscientific issues" or "socioscientific issue" or "SSIs" (plural-singular version), we decided to use only the singular version "SSI" since this term would not exclude the plural "SSIs". Moreover, we searched for the terms "socioscientific" and "socio-scientific" without the word "issue-s", even though it would retrieve results dealing with other correlates of the term, e.g. socioscientific reasoning, that we could later assess.

Consequently, the full search entry was allintitle: "ssi OR socioscientific OR socio-scientific" and "climate change", i.e., "climate change" was the necessary phrase in the publication's title, combined with the term "ssi" or "socio(-)scientific". The choice of specifying a search in the title (rather than just in the body of the text) allowed us to focus the search on more specific articles, which probably better met the purpose of our work. Hence, focusing on titles allows for the retrieval of studies that are more likely to directly address the topic of the review—namely, the use of climate change as a socio-scientific issue in educational research, rather than isolated or more specialized aspects of it. While this approach may somewhat reduce the sensitivity of the search, it simultaneously increases its precision by narrowing the results to more clearly relevant publications.

The period chosen was 2019-2024. Although the research question refers to the last five years, we have included the year 2019 since 2024 had not yet been completed at the time of our research (mid-October 2024), so that we actually have a full five-year period 2020-2024. The choice of the last five years was also appropriate because during this period the phenomena and consequences of climate change became fully visible worldwide (e.g., extreme temperatures and unprecedented weather events) as mentioned in the introduction section (Herald Sun, 2023; BBC News, 2024; Climate Adaptation Platform, 2024; WMO, 2024).

Figure 1 illustrates the methodological path of the research. Initially the search focusing on titles yielded 40 publications. However, we excluded sources that were not relevant after reading the full text beyond the title (n=8) (i.e. papers with reference to climate change but not to socioscientific issues in an educational context), as well as research that was not published following a peer review process (n=4), research in a language other than English (n=2) and research that was not accessible (1). Finally, those results that were citations to other publications were removed as duplicate records (8). This resulted in a total of 17 publications.

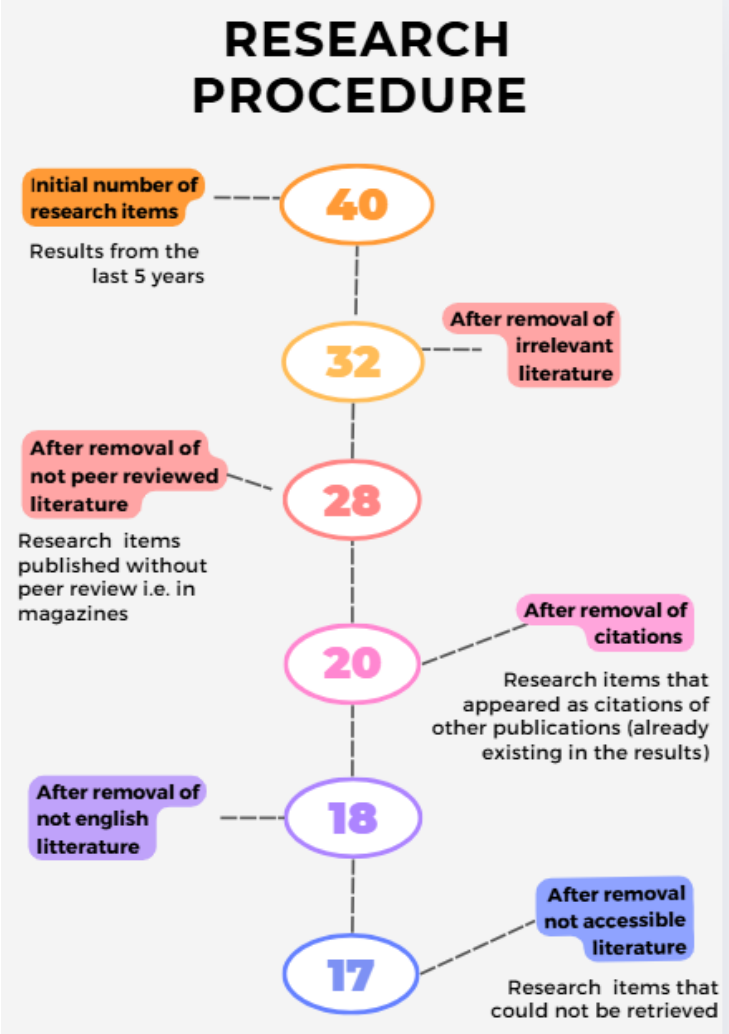

Figure 1 Methodological procedure of the research

4. RESULTS

As mentioned above, the search results yielded 17 publications related to the topic of our research. The analysis provided in Table 1 below includes the titles, authors, the date of publication, the country where the research was carried out, and a brief description of the topic of each article, with an emphasis on how CC is approached through SSIs and/or in combination with other methods. The reason for including the latter information is not only to provide an overview of the content of each article, but to shed light on how the topic of CC is approached in the classroom from the perspective of SSIs, and to clarify whether contemporary education researchers are attempting to combine different pedagogical approaches and frameworks with SSIs as regards CC. At the same time, where possible, notable findings were pointed out.

Table 1- *Overview of publications with description and/or noteworthy finding(s)*

No	Authors	Title	Country	Year	Description and/or noteworthy finding(s)
1	Dawson & Carson	Introducing argumentation about climate change socioscientific issues in a disadvantaged school.	Australia	2020	Teaching intervention for Year 10 students on the topic of CC and aiming at the development of socio-scientific argumentation.
2	Kristensen, & Knain	Which side are you on? The role of attitudes in reasoning practices in student-group interactions regarding a socio-scientific issue related to climate change.	Norway	2024	The importance of taking students' attitudes into account when organizing activities that address students' understanding of CC as a SSI and contribute to the development of a corresponding argumentation was pointed out.
3	Sanei, Kahn, Yalcinkaya, Jiang & Wang	Examining how students code with socioscientific data to tell stories about climate change.	USA	2024	A design-based research project was carried out in which high school students learned how to code and create data visualizations and stories with public data on climate change. Human impacts on carbon emissions were used as a framework. The findings suggest that the methodology used facilitated data-driven reasoning.
4	Choi, Won, Chu, Cha, Shin &Kim	The impacts of a climate change SSI-STEAM program on junior high school students' climate literacy.	Korea, Australia	2021	An educational program on the cultivation of climate literacy by combining SSI and STEAM was conducted with junior high school students, the results of which were positive.
5	Cheung, Pun & Li	Students' holistic reading of socio-scientific texts on climate change in a ChatGPT scenario.	China	2024	The impact of the use of ChatGPT and the information it provides on the understanding of the SSI of CC was studied and the findings drove a pedagogical model that improves students' holistic reading of socio-scientific texts generated by this tool.
6	Yoo, Kwak & Park	Analysis of argumentation structure in students' writing on socio-scientific issues (SSI): focusing on the unit of climate change in high school Earth Science I.	Korea	2020	In the context of the Earth Science lesson, the SSI of climate change was developed with an emphasis on global warming and the aim of developing a corresponding argumentation by the students.
7	Dawson & Eilam	Teachers' strategies to develop students' decision making skills using the socioscientific issue of climate change.	Australia	2022	Reference to the empowerment of decision-making through the study of SSIs linked to CC as one of the most important issues of the modern era and highlighting the role of teachers in this endeavor.
8	Putri, Tukiran & Nasrudin	The effectiveness of problem-based Learning (PBL) models based on socio-scientific issues (SSI) to improve the ability of science literacy on climate change materials.	Indonesia	2019	Determining the effectiveness of the problem-based learning model of SSI-based learning for improving the ability of scientific literacy in CC-related materials.
9	Powell	A socioscientific issue approach to understanding middle school students'	USA	2022	Enhancing knowledge about CC through SSI-based teaching intervention and improving the ability to produce persuasive writing on related topics.

No	Authors	Title	Country	Year	Description and/or noteworthy finding(s)
		beliefs and intentions toward climate change.			
10	Le	Keeping it cool: Approaching global climate change as a socioscientific issue to support science teachers looking to address the NGSS.	USA	2019	Proposal of a curriculum design for secondary education integrating the teaching of CC as a SSI e according to NGSS (Next Generation Science Standards) requirements and study of its implementation by teachers.
11	Won, Choi, Chu, Cha, Shin & Kim	A teacher's practical knowledge in an SSI-STEAM program dealing with climate change.	Korea	2021	Study of the teaching of CC through SSIs combined with a STEAM approach.
12	Asi, M., Retnoningsih, A., & Irsadi, A.	Effectiveness of interactive e-book global warming and climate change integrated socio scientific issues peat ecosystem.	Indonesia	2021	Materials on global warming and CC are included in an interactive e-book that integrates the peat ecosystem's SSIs. This study showed the effectiveness of the Integrated Interactive E-book SSI Ecosystem Peat on learning outcomes and students' environmental awareness attitudes.
13	Kim & Kim	Analysis of emotions of high school students participating in a school SSI club project related to climate change.	Korea	2020	Students' emotions became more positive when planning and participating in school-based SSI club project related to CC.
14	Kutluca, Çetin & Akbaş	Examination of the Evidences Used by the Secondary School Students in the Process of Socio-Scientific Argumentation: Example of Global Climate Change.	Turkey	2020	Examining students' argumentation skills in the context of SSIs with a case study on CC.
15	Yaumi, Y., & Taufikurohmah, T. ().	Development of science learning material with socio-scientific issues (ssi) on climate change materials to improve science literacy of junior high school students.	Indonesia	2019	This research aims to produce IPA learning devices with the approach of SSIs on CC materials to improve the science literacy of Junior High School students.
16	Putri, S. I., Hamidah, I., & Liliawati, W.	Analysis of needs for development of android-based socioscientific issues teaching materials on the topic of climate change to improve students' decision-making ability.	Indonesia	2023	The study found low levels of students' ability to make decisions on CC issues, and proposed development of android-based SSI teaching materials on the topic to improve their decision-making skills.
17	Baek, S., Shin, H., & Kim, C. J.	Development of a climate change SSIBL-STEAM program aligned to the national curriculum for SSI elementary school in Korea.	Korea	2022	This study describes the development of a CC SSIBL-STEAM program aligned to the elementary school national curriculum using the ADDIE model for design. Students were found to have improved their STEAM competencies, as well as their perspectives relating to moral, emotional, and convergence factors.

5. DISCUSSION

Our search yielded 17 articles that present educational research on CC as an SSI. Geographically, all continents seemed to be represented, indicating that this topic has been of interest to scientists internationally, and that they have invested time in studying it. In fact, Asia shows the highest number of studies (11/17) for these last five years, while Europe shows the lowest.

It is also noteworthy that the vast majority of research has been focusing on students, and specifically on the effect of teaching interventions on them. From our analysis of the literature, what is both interesting and important for education researchers is the type of student competencies that are attempted to be developed in each study. Thus, it seems that argumentation is the main skill studied and sought to be developed through respective interventions (Dawson & Carson, 2020; Kristensen & Knain, 2024; Kutluca et al., 2020; Yoo et al., 2020); this is not a surprise, as it is known that teaching through SSIs can be extremely helpful in developing argumentation skills (Dawson & Venville, 2009; Erduran & Jiménez-Aleixandre, 2008; author, 2013; Georgiou et al., 2020a, 2020b). Therefore, once again, the close alignment and the suitability of enhancing argumentation development within the pedagogical framework of SSIs is demonstrated. On the other hand, content knowledge is a constant pursuit and is either eventually investigated per se (Kristensen & Knain, 2024; Powell, 2022), or can be a peripheral gain of an intervention that has a different main goal (Dawson & Eilam, 2022). Furthermore, the analysis and utilization of real data, as is well known, is a superior skill that, as educators, we want students to have. Thus, the combination of CC as an SSI with data-driven reasoning looks forward to exactly this, and has been the subject of research in the last five years (Sanei et al., 2024). Moreover, the research also identified different, rather daring, combinations of frameworks, e.g., with STEAM (Choi et al., 2021) or with problem-based learning (Putri et al., 2019).

In general, several of the articles refer to environmental literacy and the anxiety in the scientific community to develop this literacy in students as much as possible in order to develop their environmental awareness (e.g. Petri et al., 2019; Yoo et al., 2020; Asi et al., 2021) . It is obvious, then, why SSIs are studied and evaluated as an appropriate context since they strongly involve the moral and ethical dimension (Zeidler, 2024; author, 2024). This has led to some studies focusing on students' emotions (Kim & Kim, 2020) and the attitudes relating to concern for the environment they develop when engaged in CC SSIs (Asi et al., 2021).

In addition, in sync with our intensively digital age, some studies explored the possibilities of applying AI when studying CC in a socio-scientific light (Cheung et al., 2024), or even the use of an e-book (Asi et al., 2021). Proposals for developing appropriate android-based software (Putri, 2023) to enhance skills mentioned above (e.g., decision making) were also presented.

Although as previously noted the majority of the research focused on students, research was also identified that focused on teachers studying their own fluency as regards teaching CC as an SSI (Won et al., 2021). It has already been found that in general several teachers find it difficult to use this pedagogical framework, and therefore avoid it (Dawson, 2011; Sadler et al., 2006); this does not imply that this finding is universally true (Dawson, 2011), but it is certainly worthy of additional study. Finally, with this kind of facilitation in mind, i.e., ensuring appropriate conditions for SSI-based teaching of CC, a curriculum proposal following the principles of the NGSS (Next Generation Science Standards) was presented (Le, 2019).

While the reviewed studies offer valuable insights into teaching CC as a SSI, several important areas remain underexplored. Notably, there is limited investigation into how CC SSIs can be effectively integrated into early education levels or non-formal learning settings, such as museums (Georgiou et al., 2022) or community programs (e.g. citizen science). Additionally, although student competencies like argumentation and data-driven reasoning were frequently addressed, there is a lack of emphasis on students' decision-making processes in authentic social contexts or how these are influenced by cultural or socio-economic factors. Research on teachers was scarce and largely descriptive; thus, deeper studies into professional development models that support teachers in adopting SSIs, particularly in under-resourced or diverse classrooms, are needed. Finally, the ethical dilemmas and emotional challenges that arise when engaging with controversial CC topics in the classroom deserve more focused attention, as these are key to shaping responsible, critically aware citizens.

As regards our research, it is important to note that the results may be different to some extent if the search criteria are changed or broadened. It is likely that additional studies have been conducted on the same or a similar topic or approach, even if that was not their primary focus. As a result, the topic might not be explicitly mentioned in the article's title and therefore not captured by our search parameters.

Despite of these limitation, our study allowed to capture the trend of teaching CC, and analyse how was it combined with the pedagogical framework of SSIs as a means of shifting students' social awareness to a broader level. In other words, CC has been treated as a phenomenon of educational interest, and examining it as a SSI, its social dimension, which has at the same time a scientific background, becomes apparent; it is an issue which affects every living thing on the planet, and an issue which needs to be addressed collectively.

Although at first glance, the 17 articles published over the last five years may seem like a small number, we should give serious consideration to the findings of the review. We need to evaluate the positive trend it reveals and, of course, strengthen the study by enriching it with new research. This should always be done in the direction of promoting scientific literacy. Such literacy should not only relate to Vision I—meaning the basic acquisition of scientific knowledge, concepts, and processes—but even more so align with Vision II and Vision III. These latter perspectives emphasize the application of knowledge in real-life contexts, the development of critical citizenship, and scientific "knowing-in-action" (Roberts, 2007; Aikenhead, 2007; Zeidler & Sadler, 2023), all of which are necessary to address the needs of our time.

6. CONCLUSION AND IMPLICATIONS

It is quite encouraging that education scientists are interested in addressing the issue of CC and have conducted research on it worldwide. Our own research focused on the last five years, a time when extreme weather and environmental phenomena have exceeded even the imagination (disastrous windstorms, extensive wildfires, sweeping floods, record-breaking global temperatures, etc.) (e.g. Herald Sun, 2023; BBC News, 2024; Climate Adaptation Platform, 2024; WMO, 2024).

It is worth noting that researchers have commonly addressed the issue of CC in contexts other than SSIs, an engagement which results in educational benefits. However, it has been shown that the SSI framework can be combined with a number of other frameworks through the CC paradigm to yield educational benefits and gains. In addition the targeted

approach through SSI can go a step further by promoting the moral and ethical aspects of this issue.

In conclusion, the integration of CC as SSI in education is crucial for the development of informed, responsible and active citizens. Although there are challenges in its implementation, the benefits for scientific literacy and active citizenship make it a valuable component of modern education. Thus, on the one hand, education researchers should focus on developing effective pedagogical strategies and supporting teachers in overcoming barriers to teaching CC. In this way, teachers will be better equipped to empower their students towards scientific literacy. Therefore, it is important for policymakers, and subsequently teacher trainers, to take the above into consideration by adopting the incorporation of SSIs, and more specifically SSIs that promote CC education, in curricula and teacher training programs.

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