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Climate Change Education in Secondary and Tertiary programs

A systematic review

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Master dissertation
Master in de opleidings- en onderwijswetenschappen

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Approach and contribution

This master thesis originated from collaboration with De Wetenschapswinkel, an organisation that serves as a point of contact for non-profit organizations seeking scientific support through student research within the context of a final project. I was very interested in the topic: “How Can we Skill Youngsters to Establish Sustainable Communities (and Become a Member of It)? Evidence on Technical and Vocational Education and Training (TVET) Programmes across the Globe”. Professor Peter Van Petegem agreed to be the supervisor.

During the first meeting in October 2022, the expectations of all stakeholders, including Sofie Cabus representing VVOB, Eva Van Moer representing De Wetenschapswinkel, myself as a master's student, and Professor Peter Van Petegem as the supervisor, were aligned. VVOB recommended the report ‘Education for climate action’ by Suzanne Ehlers et all. (2022) as a starting point for this study. I also attended the ‘Educaid’ conference organised by VVOB to familiarize myself further with the topic of climate change education. I was advised to look into the PRISMA statement to as guidance for conducting my review. Additionally, my supervisor recommended that I explore the article “Climate Change Education and Research: Possibilities and Potentials Versus Problems and Perils?” (Reid, 2019) to gain a good understanding in the field of climate change education. Throughout the research process, I also came in contact with Arne Willems and Sharon Schroen from VVOB through email.

The original research question was about skilling youngsters for sustainable community establishment, particularly in the context of Technical and Vocational Education and Training (TVET) programs globally. However, due to limited research on this topic, there were two possible pathways to broaden the scope of the review. The first option was to keep the focus on technical and vocational education and training, but expanding the search towards not only climate change education (CCE) but also environmental education (EE) and education for sustainable development (ESD). The second option would be to keep the focus on climate change education but expand from only TVET-focused research to secondary and tertiary education. After consulting with Professor Van Petegem, the decision was made to go for the second option. As a result, this study now delves into climate change education in secondary and tertiary education, allowing for a more comprehensive investigation.

The original list of research questions was very extensive, also including goals, outcomes, categorization of studies in high-income-countries and low-and-medium-income countries and making a comparison between both. Throughout the process, the decision was made to narrow down toward the chronological evolution of CCE publications, their geographic representation, the educational settings in which the CCE programs are implemented and the predominant themes within CCE programs. All decisions regarding the methodology, data analysis and reporting were made independently.

I want to thank Professor Peter Van Petegem for the guidance throughout this trajectory, as well as the follow-up from Eva Van Moer, Sophie Cabus and Arne Willems. I hope my master’s thesis can contribute to the valuable work VVOB is doing for quality education and creating equal opportunities for everyone in Flanders as well as abroad.

I would like to express my appreciation to my mother Bianca Tomasetig for proofreading my thesis and giving support and advice throughout this process. Also I acknowledge the use of AI for correcting grammar and spelling mistakes in this thesis (OpenAI, 2021). However, remaining errors or shortcoming are my sole responsibility.

Abstract

(English)

Despite the urgency of the climate crisis, climate change education (CCE) remains a relatively underexplored domain. Through a systematic review, this study investigates the demographic characteristics and the design of educational programs related to climate change. The research explores the chronological evolution of CCE publications, their global representation, the educational settings in which CCE programs are implemented, and the prevalent themes within CCE programs, using the PRISMA method for systematic reviews. The findings indicate a noticeable growth in the research field, a lack of representation in low-and-middle-income countries, and an overrepresentation at the higher secondary educational level. Moreover, the findings highlight a significant emphasis on climate literacy within these programs, while the affective dimension is relatively neglected. This study not only provides valuable insights into the state of CCE but also establishes the groundwork for more inclusive and holistic climate education strategies. Such strategies are imperative for adequately preparing the younger generation to confront the challenges of climate mitigation and adaptation in an increasingly climate-vulnerable world.

(Nederlands)

Ondanks de urgentie van de klimaatcrisis blijft klimaatverandering educatie (KVE) een relatief onontgonnen gebied. Door middel van een systematische review onderzoekt deze studie de demografische kenmerken en het ontwerp van educatieve programma's met betrekking tot klimaatverandering. Het onderzoek verkent de chronologische evolutie van KVE-publicaties, hun wereldwijde vertegenwoordiging, de onderwijsinstellingen waarin KVE-programma's worden geïmplementeerd, en de dominante thema's binnen KVE-programma's, gebruikmakend van de PRISMA methode voor systematische reviews. De bevindingen geven een opvallende groei in het onderzoeksveld aan, een gebrek aan vertegenwoordiging in landen met een gemiddeld inkomen en een oververtegenwoordiging op het niveau van het hoger secundair onderwijs. Bovendien benadrukken de bevindingen een aanzienlijke nadruk op klimaatgeletterdheid binnen deze programma's, terwijl de affectieve dimensie relatief wordt verwaarloosd. Deze studie levert niet alleen waardevolle inzichten in de staat van KVE, maar legt ook de basis voor meer inclusieve en holistische educatieve strategieën met betrekking tot klimaatverandering. Dergelijke strategieën zijn van essentieel belang om de jongere generatie adequaat voor te bereiden op de uitdagingen van klimaatmitigatie en -adaptatie in een steeds klimaatkwetsbaardere wereld.

Blogpost

Exploring Climate Change Education: A closer look at programs across the globe

When we think about climate change, it's not just about melting ice caps and extreme weather events; it's about our future and the world we're leaving for our children. We often find ourselves wondering why more isn't being done to tackle this global crisis.

If you're like me, you might have had the same thought: "I didn't learn enough about climate change in school!" The good news is that many teachers are starting to include it in their lessons. However, there's still a long way to go, and surprisingly, there hasn't been as much research on climate change education as you might expect. So, I decided to dig deeper. I explored how climate change education programs are designed around the world, and I want to share what I discovered with you.

Unveiling Insights

In my research, I conducted a systematic review of climate change education in secondary and tertiary schools. I wanted to understand the bigger picture: How are these programs evolving over time? Where are they happening? Who is involved? And what are they focusing on?

What We Uncovered

Here's what I found, presented in a way that's easy to grasp:

1. Expanding Horizons: Over the past few years, there's been a surge in research in the field of climate change education. It's exciting to see that more people are recognizing its importance.
2. Global Hotspots: The majority of these programs are happening in the United States and the European Union. It's a great start, but we need more global participation.
3. Educational Settings: Most of these programs are currently offered in higher secondary education. That's fantastic, but we need to expand to other educational levels too.
4. Popular Topics: The programs tend to focus heavily on climate literacy and science-related aspects. While these are essential, we also need to address the emotional and behavioural aspects of climate change.

The Way Forward

So, what's the way forward? Based on what we've learned:

1. Worldwide Reach: Climate change education programs should spread across the globe. Everyone, no matter where they live, should have access to this crucial knowledge.
2. Diverse Settings: We need to diversify the educational settings. It shouldn't just be limited to higher secondary education. Let's bring it to lower secondary education and even informal learning environments.
3. Beyond Knowledge: While knowing about climate change is essential, it's equally vital to understand the emotional and behavioural responses it triggers. Knowledge alone isn't always enough to inspire action.

A Call to Action

Climate change education is our tool for a brighter future. It's not just about learning facts; it's about taking action to protect our world. As we continue to expand these programs, let's remember that we all play a part in shaping a sustainable world for generations to come. It's a journey we're all on together, and every step counts.

Contents

Introduction

Our planet is confronted with rising droughts, fires, storms and melting ice. The Intergovernmental panel on Climate Change (IPCC) revealed in its sixth assessment (2023) that climate change (CC) has widespread impacts nature, health, food and water security, affecting the well-being of current and future generations. Future risks will escalate rapidly with every fraction of a degree of warming. Human activities have unquestionably driven global warming, pushing global surface temperatures to 1.1°C above pre-industrial levels in the last decade (Intergovernmental Panel on Climate Change, 2023). Greenhouse gas emissions are at record highs, promising long-lasting climate changes and increased pollution in the air, soil, water, and oceans.

High-income countries bear the most responsibility for emissions: the 10 highest emitting countries are responsible for 70% of the global emissions (United Nations Children's Fund, 2021). Low-and-middle-income countries (LMICs) on the other hand, who contribute the least, endure the brunt of the consequences. The climate crisis also disproportionately impacts children's lives, since it threatens their right to life, health and education. Nearly half of all children, around 1 billion, are classified as being at "extremely high risk" according to UNICEF (2021). Yet, the IPCC offers hope amid this crisis, outlining actionable steps to reduce emissions, remove carbon, and build resilience (2023). Immediate action is essential; global greenhouse gas emissions must peak by 2025, nearly halve by 2030, and reach net-zero by 2050. Achieving this transformation will require collaboration between governments, the private sector, civil society and individuals (IPCC, 2023). Immediate action is our only path forward.

Education plays a crucial role in addressing climate change, as it fosters awareness, knowledge, and action. The latest IPCC report emphasizes that enhancing climate literacy and education can promote behavioral changes and reduce greenhouse gas emissions (2023). Historically, environmental education (EE) emerged from the Tiblisi conference in 1977, focusing on biodiversity, sustainability cand responsible interaction with nature (Intergovernmental Conference on Environmental Education, 1977). Education for Sustainable Development (ESD) later gained attention, concentrating on social, economic, and environmental dimensions (Mochizuki & Bryan, 2015; The United Nations Educational, 2022). Climate Change Education (CCE) stems from these two frameworks, aiming to educate on climate change causes and solutions (Cordero et al., 2020).

CCE has demonstrated positive impacts, with students retaining pro-environmental attitudes years after completing climate change courses (Cordero et al., 2020). Implementing similar programs for secondary school pupils could reduce emissions significantly (Cordero et al., 2020). However, despite its potential, CCE has not received the necessary priority in addressing climate change (Busch et al., 2019). There's a lack of understanding of how education can enhance climate literacy and drive behavioral change (Ehlers et al., 2022; Rousell & Cutter-Mackenzie-Knowles, 2020).

A good way to get a grip on the trends in the research field is through a review study of the existing literature. Several significant review studies exist within the field of climate change education. Monroe et al. (2019) conducted a review study that had a big impact on the CCE field. This review aimed at identifying effective climate change education strategies. They conducted an extensive search using the academic database EBSCOhost. This review focused on the purpose of interventions, assessment methodologies, and the identification of strategies that could lead to effective interventions. Rousell and Cutter-Mackenzie-Knowles (2020) carried out a systematic research review covering various age groups in climate change education, focusing on children and young people. Their objective was to

identify key areas for further research and innovation in the field. This review analysed existing literature from 1993 to 2014. Nepras et al. (2022) conducted a systematic review specifically analysing papers that concentrated on climate education for ISCED 1 and 2 students, which corresponds to primary and lower secondary education. Their findings highlighted differences in climate change education approaches for younger children: older students benefited from a more holistic and abstract approach, while younger students thrived with place-based approaches.

However, there hasn't been a study conducted specifically for students in secondary and tertiary education levels. This research gap encouraged me to conduct a systematic review targeting this specific age group. This focus is crucial because there are notable differences in educational needs based on age, particularly within secondary and tertiary education. I use the International Standard Classification of Education (ISCED) 2011 to determine the age groups of the target audience (Eurostat, 2011). ISCED categorizes education into nine levels, spanning from early childhood to doctoral levels. In this review, my primary focus is on ISCED levels 2, 3, 4, 5, 6, and 7, which respectively correspond to lower secondary education, upper secondary education, post-secondary non-tertiary education, short-cycle tertiary education, bachelor's or equivalent level, and master's or equivalent level.

Theoretical framework

The theoretical framework guiding this study draws upon diverse perspectives related to climate change education (CCE), with a particular focus on demographics, as well as various educational programs.

Nepras et al. (2022) observed a noticeable surge in published articles on CCE. Although they monitored the period from 2001 to 2020, their study only included publications from 2009 to 2020, with a significant rise occurring predominantly between 2018 and 2020. In contrast, Rousell and Cutter-Mackenzie-Knowles (2020) had a broader temporal scope, spanning from 1993 to 2014. They documented a substantial increase in publications beginning in 2009. These findings align with Monroe et al. (2019), indicating an escalating interest in research on integrating climate education into curricula. Rousell and Cutter-Mackenzie-Knowles (2020) highlighted that the United States exhibited the highest concentration of CCE publications, followed by Canada and the European Union. However, more recent years have witnessed a growing number of studies from other countries. Nepras et al. (2022) also reported similar geographical disparities, with 16 out of 43 studies originating from the United States and 17 from the European Union. Monroe et al. (2019) revealed a predominant focus on publications related to primary and secondary schools, as well as colleges and universities. Elementary programs were less common, and informal settings received limited attention. Rousell and Cutter-Mackenzie-Knowles (2020) observed a similar trend, with more publications in secondary and tertiary education compared to primary education and informal settings. Nepras et al. (2022) pointed out an underrepresentation of ISCED 1 areas, particularly within the age group of 6 to 9 years old.

Previous systematic reviews within the CCE domain have contributed valuable insights for frameworks in CCE. The goals of CCE have been classified the same way as education for sustainable development. This classification into cognitive, socio-emotional, and behavioural outcomes was proposed by UNESCO (2017). This framework is echoed by Szczepankiewicz, who presents a comprehensive model of climate education management, also emphasizing the importance of cognitive, socio-emotional and behavioural objectives (Szczepankiewicz et al., 2021). Another innovative approach is the "bicycle model", proposed by Finnish researchers, which segments climate change education into components

analogous to different bicycle parts, ensuring a holistic approach to program design (Tolppanen et al., 2019). These elements are knowledge and thinking skills—wheels; values, identity and worldview—bicycle frame; motivation and participation—saddle; future orientation—handlebars; hope and other emotions—light; action—chain and pedals; operational barriers—breaks.

Further insights can be drawn from a thematic categorization of CCE content, encompassing six topics: climate understanding, warming awareness, human responsibility, consensus among experts, recognition of negative impacts and the potential for solutions. These six topics are referred to as "It's climate, it's warming, it's us, experts agree, it's bad, we can fix it" (Wynes & Nicholas, 2019). Ultimately, Ehlers and colleagues propose three interconnected domains for the role of CCE in addressing the climate crisis: promoting climate literacy for collective action and behaviour change, cultivating green skills for a sustainable economy, and building adaptive capacity (Ehlers et al., 2022). Monroe and colleagues identified two overarching themes: the personal relevance of climate change information and learner engagement through activities or interventions (Monroe et al., 2019).

Apart from several ways of classifying, there are also important insights on which topics need more or less attention within CCE. Previous research has revealed several key findings: while knowledge is recognized as important (Kolenatý et al., 2022), the relationship between knowledge and behaviour remains unclear (Dijkstra & Goedhart, 2012). CC curricula have been criticized for focusing too heavily on human warming, often neglecting other critical aspects such as scientific consensus, impacts or solutions (Wynes & Nicholas, 2019). A similar conclusion can be drawn from an interpretation of Biesta's (2020) model highlighting the three functions of education. It emphasizes that qualification (understanding why addressing climate change is crucial) alone is insufficient. Students also require the socialization domain to develop the skills for collaborating with others in addressing climate issues within their communities, and the subjectification domain to cultivate a sense of personal responsibility (Monroe et al., 2019). Successful CCE programs often integrated four specific components in their review: deliberative discussions, interaction with scientists, addressing misconceptions and implementing projects (Monroe et al., 2019). The review of Rousell and Cutter-Mackenzie-Knowles (2020) identifies the need for participatory, interdisciplinary, creative, and affect-driven approaches to climate change education, which to date have been largely missing from the literature.

This literature review aims to find an answer to following main research question: How are education and training programs in secondary and tertiary education designed to address climate change?
I specified four subquestions:

1. In the context of secondary and tertiary education, how has the chronological evolution of publications on CCE progressed over time?
2. What variations exist in the geographic representation of CCE publications in secondary and tertiary education?
3. In which educational settings are CCE programs primarily implemented in secondary and tertiary education?
4. What specific topics emerge as predominant within CCE programs designed for secondary and tertiary education?

Methodology

The internationally followed guidelines of The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) were used for the selection of the studies. Two sets of search terms were used to find relevant studies (see table 1): the first set identified CCE-related studies and the second set narrowed the scope to secondary and tertiary. The two sets were separated by the operator 'AND' to make sure each study included at least one search term from each set. The operator 'OR' separated different search terms from the same set. Choosing search terms involves finding a middle ground between making the search wide-ranging to include pertinent content while also ensuring it's focused enough to facilitate a manageable review process.

Table 1.

Search terms used.

Climate change education	Operator	Type of education
"climate change educat*" OR "climate educat*" OR "climate literacy"	AND	"secondary educat*" OR "secondary school*" OR "high school*" OR "tertiary educat*"

All data bases of Web of Science, EBSCOhost and Proquest within the scope of the University of Antwerp's licence agreement were searched on July 22 of 2023. This search included the data bases ERIC, Sustainability, GreenFile, Environment Index, Academic Search Premier, Education Full Tekst, PsychInfo, Environmental Education Research and many more. Additionally, I searched the journal of Environmental Educational Research separately since the database searches did not consistently return all results from this journal. There was no limit to the year of publishing of the studies, nor did I use any filters or limits. The search resulted in 283 studies: 106 from Web of Science, 146 from EBSCOhost and 31 from ProQuest. After removing duplicates 234 studies remained.

Articles were selected in two phases. In the first phase, the studies were screened by reading their titles and abstracts. 133 records were excluded. Common reasons for exclusion in this phase were: the record describes a book instead of a study, the central theme of the research is misconceptions or implicit views regarding CCE, the target audience is the teacher instead of students. In the second phase, the full text of the remaining studies was read to check the suitability for my research. 45 reports were excluded regarding the following exclusion criteria: (1) The central topic of the report is not a CCE program; (2) the target audience is not secondary or tertiary education; (3) the report is no empirical research; and (4) there are no reported outcomes. Eventually, 26 studies remain for the review. The complete process of selecting the studies is illustrated in Figure 1, created in the PRISMA flow diagram tool (Haddaway et al., 2022). A table of all included publications can be found in attachment 1.

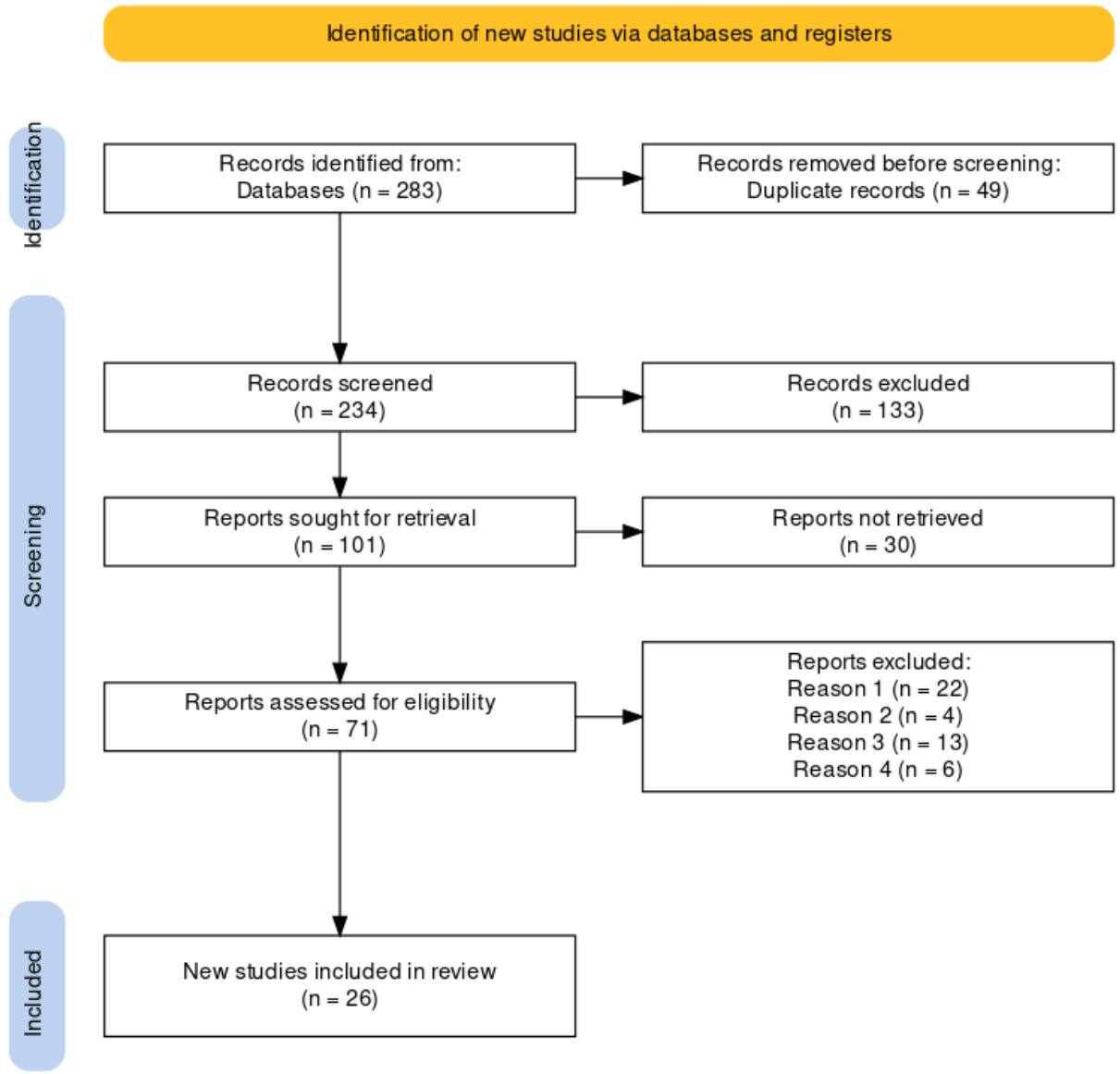
A thorough review of the literature was conducted to identify key themes and categories related to CCE in secondary and tertiary education: these themes included the years of publication, the countries where the programs took place, the program setting and the topics covered. The identified themes are coded and grouped into meaningful clusters with the help of the software NVIVO. Information such as the year of publication was automatically registered when the references were transferred from EndNote to NVIVO. After collecting all information in the clusters shown in attachment 2. the data was both quantitatively and qualitatively assessed. For questions related to publication year, program country and educational setting, I employed quantitative analysis.

For addressing the first research question, which delves into the chronological evolution of CCE publications, I sought to achieve the following outcomes: identifying the distribution of CCE publications across different timeframes and identifying any notable increases or decreases in the volume of CCE publications. Moving on to the second research question, pertaining to the representation of countries within CCE programs, my aim was to list and quantify the nations where these programs have been executed. Moreover, I aimed to calculate the prevalence of CCE programs in diverse countries. The third research question, concerning the diverse settings of CCE programs, I categorized the different educational settings where CCE programs are conducted. In addition, I aimed to ascertain the prevalence of CCE programs within each distinct educational setting.

To address the fourth research question regarding prevalent topics in Climate Change Education (CCE) programs, an inductive approach was employed for data collection and analysis using NVIVO software. Through this inductive coding process, themes and patterns related to CCE topics emerged directly from the data. Subsequently, in order to enhance the clarity and interpretability of the findings, the inductively generated topics were categorized into fourteen distinct thematic clusters. The methodological approach focused on addressing research questions, and while data on program goals and outcomes were collected for contextual understanding, they were not incorporated into the analysis for this review.

Figure 1.

Prisma 2020 flow diagram describing the selection of studies for analysis



The outcomes corresponding to each research question were organized into tabular format using NVIVO software to visually present the results. This approach aimed to balance the insights drawn from the data with the need for a structured and coherent presentation of findings, ultimately providing a meaningful and nuanced understanding of the diverse topics within climate change education.

In conducting this review, it is crucial to acknowledge several limitations and potential biases that may have influenced the findings and interpretations. These considerations underscore the need for caution when generalizing the results. One significant limitation to be aware of is the possibility of publication bias. This arises from the inherent tendency in academic publishing to favor studies with positive or statistically significant results, potentially leading to an underrepresentation of studies with negative or null findings. Additionally, the review focused primarily on resources published in English and accessible through the University of Antwerp's licensed peer-reviewed literature databases, namely EBSCOhost, Web of Science, and ProQuest. This focus on specific search criteria and language

might have caused us to miss relevant research not perfectly aligning with our criteria. Many researchers publish their work in languages other than English, which could have resulted in language bias. Another potential source of bias relates to the geographical scope of the selected studies. Our reliance on databases accessible through the University of Antwerp's license might have inadvertently introduced geographical bias into the selection of studies. Some databases could have a bias toward research from specific regions, potentially limiting the representation of global perspectives.

We also need to consider the impact of our exclusion criteria. For example, the decision to exclude studies focusing on teacher perspectives rather than students might have led to the omission of valuable insights into climate change education. Furthermore, the exclusion of non-empirical research, while a deliberate choice, may have left out important theoretical or conceptual papers that could provide essential context for the empirical studies included. Additionally, we did not incorporate gray literature, such as conference proceedings, theses, dissertations, and evaluation reports, into our review due to their challenging searchability. These sources might contain valuable insights that could complement the findings. Lastly, it's essential to recognize the variability in the programs included in this review. Some were short interventions, such as field trips, while others constituted multi-week units. Variability also existed in the context of the programs, with some being part of university courses and others reporting on entire courses. This variety might have influenced the coding process and introduced some subjectivity. Despite these limitations and potential biases, it is reasonable to be confident that the findings are based on a diverse and representative sample. While the results should be interpreted with awareness of these limitations, they nevertheless provide valuable insights and implications for climate change education.

However, there are additional constraints to consider in this study. My fundamental assumption revolves around identifying how climate change education programs are designed in the contexts of secondary and tertiary education through evaluated programs. This approach depends on authors, often program developers, educators, and evaluators themselves, describing the efficacy of their interventions. Evaluation studies, which may not primarily focus on the assessment of climate change education, are sometimes not extensively published in peer-reviewed literature. This leads to the orientation of these articles focusing on specific strategies or comparisons rather than solely on the assessment of climate change education interventions. It is also important to acknowledge the methodological approach utilized in this review. While the study counted the frequency of topic occurrences, it did not measure the relative emphasis each topic received within individual programs. As a result, topics briefly mentioned may carry the same weight as those extensively covered, potentially confounding the proportional representation of themes. Additionally, a significant body of literature discusses interventions that are not quantitatively tested, a dimension not included in my review. These studies, although not evaluated in the traditional sense, offer crucial insights into the nuances of how individuals comprehend climate change, the obstacles in understanding it, and potential educational methods. This opens avenues for another review focusing on synthesizing these diverse types of publications, potentially expanding our understanding of climate change education and offering innovative perspectives on instructional strategies.

Results

This section outlines the findings derived from the examination of the selected studies. First, an outline of the results from the descriptive quantitative analysis will be provided. In the following sections, the results of the qualitative analysis focusing on the topics of CCE programs are presented.

Figure 2 shows the years studies included in the review, were published. Although there was no limit to the year of publishing of the studies, only studies from 2003 up to 2022 were included in the final selection. Only 2 studies took place before 2013. Additionally, there are no publications included from 2017 and 2018. 50% of all studies included are published since 2020.

The distribution of CCE programs across countries is uneven. The majority of the programs were conducted in the USA (n=8), the European Union (n=7) or Canada (n=4). A limited number of programs were carried out in low-and-middle-income countries, including India, the Philippines, Malaysia, and Ghana, each having one representation. In percentage, this means 30.77% of all studies are carried out in the USA 26.92% in the EU, 15.38% in Canada and only 19.23% in all low-and middle-income countries together. Additionally, four studies involved collaborative efforts among researchers from various countries, while these programs were being implemented in schools across different nations. For a visual representation, please refer to figure 3.

I categorized the study settings into four groups: lower secondary education, which corresponds to ISCED 2; higher secondary education, aligned with ISCED 3; university education, encompassing ISCED 5, 6, and 7; and informal education, occurring outside of the traditional classroom environment (figure 4). The majority of the studies were conducted in higher secondary education. Only one study focuses on informal education. This study discusses the educational program of a “climate club”. It's worth noting that certain studies span multiple settings, which is why the total category count exceeds the number of studies included in the review. Studies across various settings exhibit the following distribution: 50% encompass lower secondary students, 88.46% involve higher secondary students, 26.92% engage university students, and 3.84% encompass students from informal education.

Figure 2.

Number of publications per year published

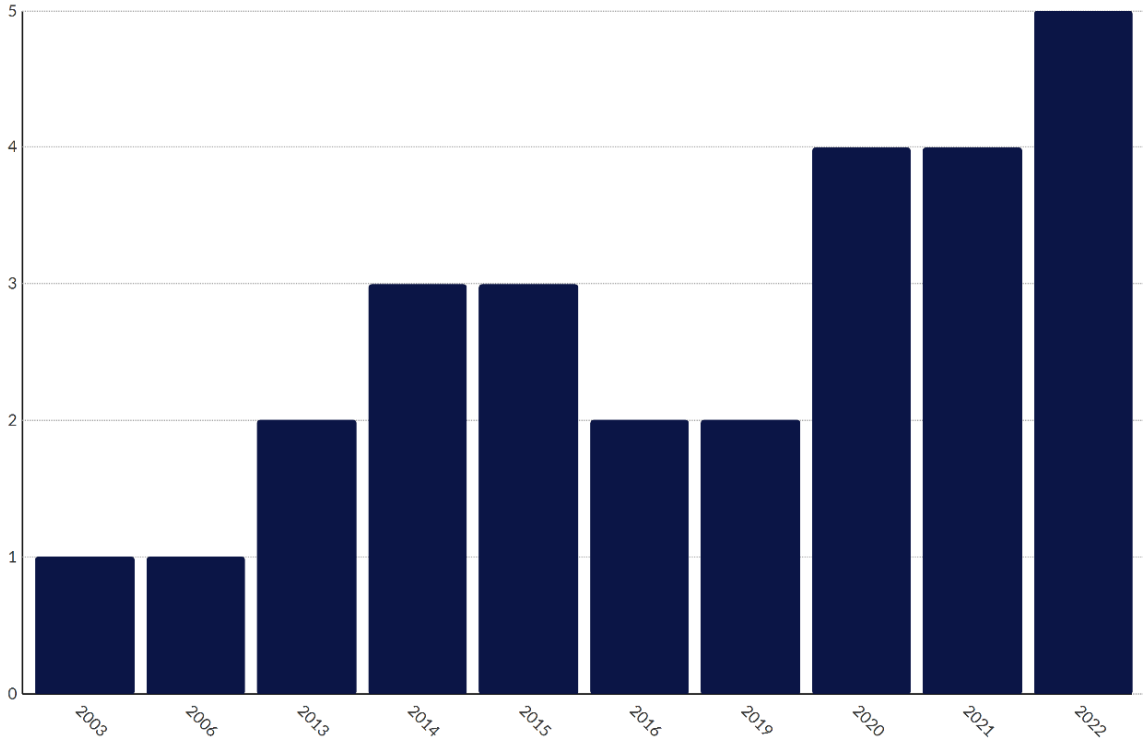


Figure 3.

Number of publications per country

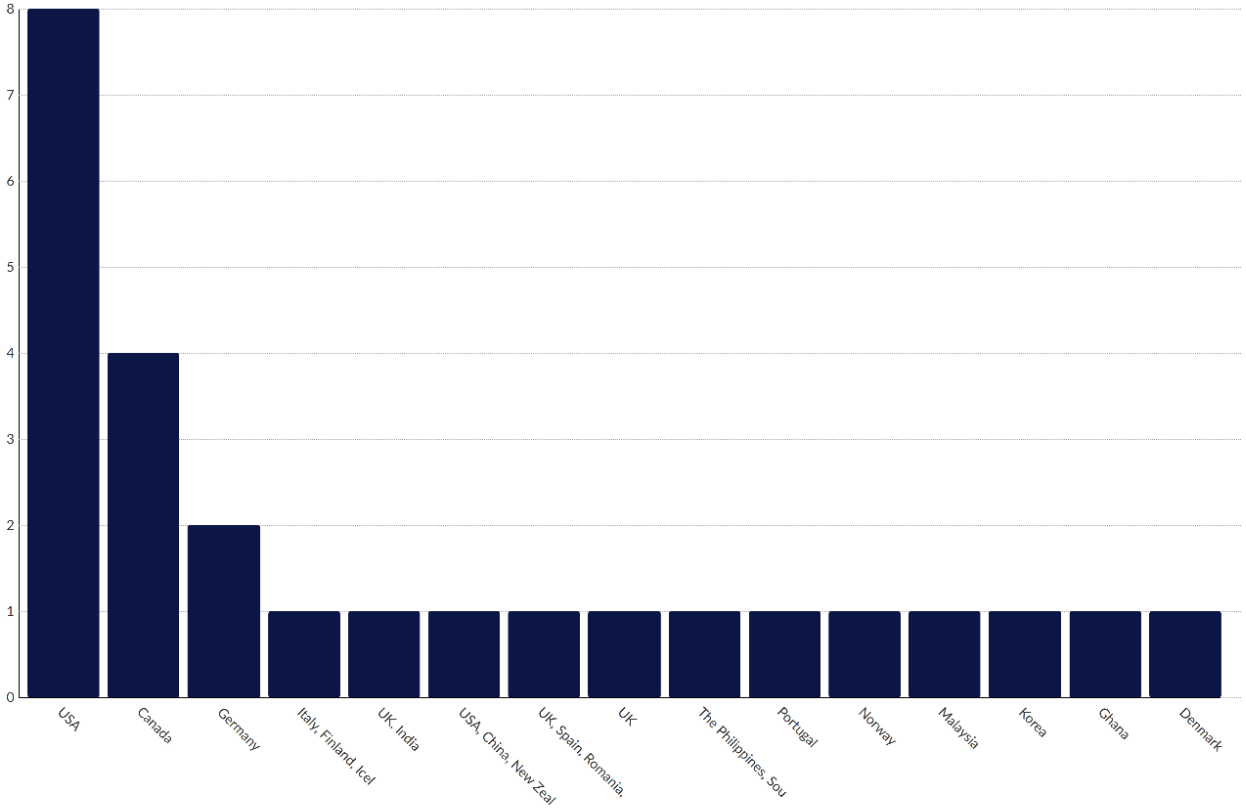


Figure 4.

Number of publications per program setting

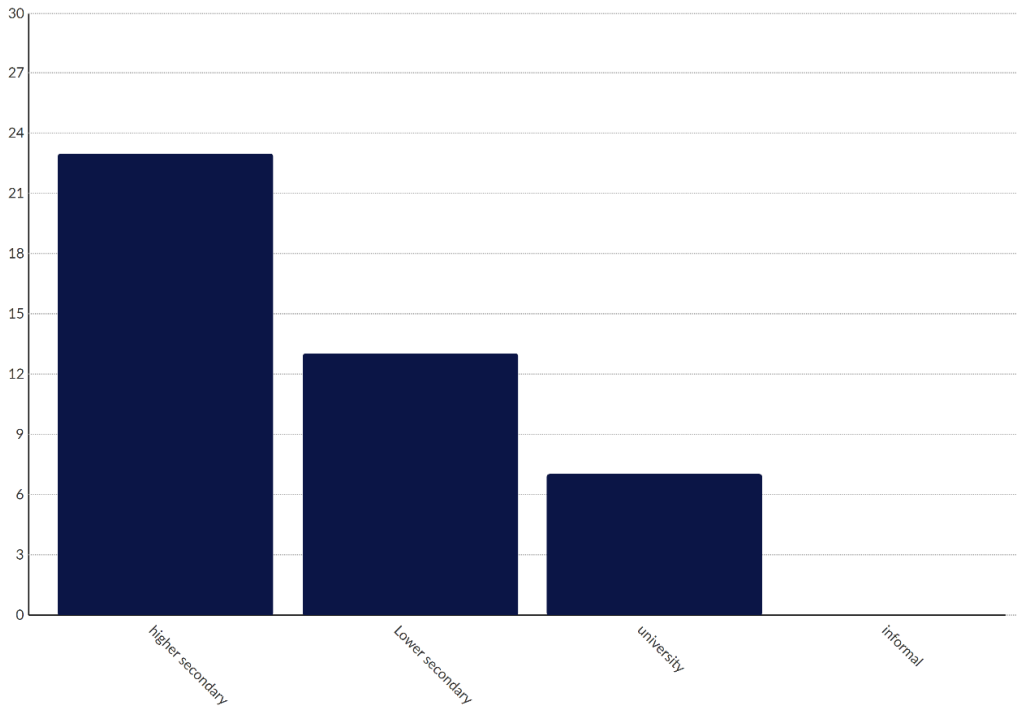
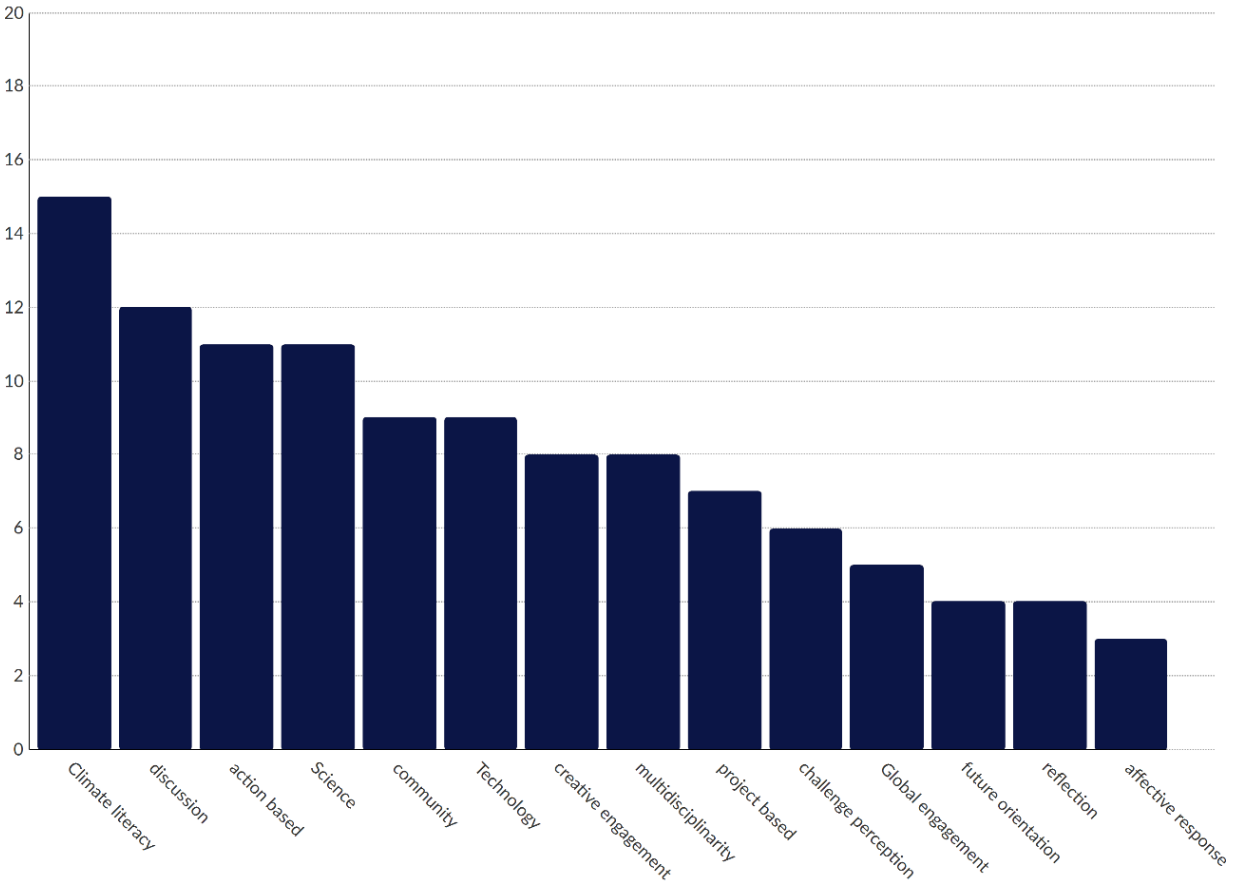


Figure 5.

Number of programs per topic



My focus lies in determining how frequently each topic appears in various programs. Given that educational programs often cover multiple topics, a single program may be represented in several columns. Figure … shows an overview of the most coded topics occurring in CCE programs. Climate literacy is part of 15 CCE programs, making it the most popular topic in this review. It is followed by discussion, action based and science. Only topics that occur in at least three different programs are included.

Climate literacy: The concept of climate literacy is a central theme within CCE, encompassing a range of aspects aimed at enhancing individuals' understanding of climate-related issues. Various studies have explored this topic, shedding light on the different dimensions of climate literacy. For instance, Brumann et al. (2022) identified climate literacy as an outcome, emphasizing the importance of understanding climate-related concepts on both a global and regional scale. Boakye's study sheds light on enhancing individuals' understanding of climate-related concepts, emphasizing the need to establish links between climate change education and curricula topics such as "Ecosystems," "Photosynthesis," and "Energy" (Boakye, 2015). Jones et al. (2022) delved into topics like "building concepts", indicating efforts to improve students' comprehension of climate change through educational interventions. Karpudewan et al. (2015) highlighted key concepts related to climate change, such as "acid rain", "greenhouse effect", "global warming", and "ozone layer depletion", underlining the necessity of knowledge acquisition in CCE. Similarly, these and several other studies (Korsager & Slotta, 2015; Petersen et al., 2020; Powers et al., 2021; Sellmann & Bogner, 2013) collectively underscore the importance of climate literacy in education, with each study offering unique insights into how this knowledge is approached and cultivated within the context of climate change education.

Science: The inclusion of science as a fundamental component in climate change education is evident across various studies. Studies such as Alexandru et al. (2013) emphasize that science remains the primary medium through which climate change is taught. This is further reinforced by Arya and Maul (2016), where students interacted with volunteer scientists from diverse fields. In the program of Cox et al. (2014), students studied geosciences by analysing climate change data from NASA satellites. Karpudewan et al. (2015) emphasizes the value of hands-on laboratories in science education. Park and Kim (2020) develop scientific models to understand climate causes. Rudd et al. (2020) discuss science's role in interdisciplinary climate education. Additionally, Pruneau et al. (2003) and Pruneau et al. (2006) spotlight science-related experiments. Students took on the role of meteorologists, chemists and urban planners. In summary, science forms the foundation for understanding climate complexities across diverse educational approaches.

Technology: Technology plays a crucial role in CCE, as seen across multiple studies. Arya and Maul (2016) advocate for open-source learning platforms, emphasizing eLearning and online collaboration. Bush et al. (2019) introduce EdGCM, a real climate research tool for public engagement. Cox et al. (2014) analyse climate data using NASA satellite information. Petersen et al. (2020) adopt Immersive Virtual Reality (IVR) for innovative virtual field trips. Rudd et al. (2020) promote digital literacy through interactive digital fiction.

Multidisciplinarity: The concept of multidisciplinarity is a recurring theme in CCE, as evidenced by various studies (Alexandru et al., 2013; Arya & Maul, 2016; Bentz, 2020; Breslyn et al., 2016; Jones et al., 2022). Levrini et al. (2021) underscore the significance of systems thinking, emphasizing interconnectedness. Park et al. (2020) discuss the incorporation of socio-scientific issues in CCE,

illustrating the multidimensional nature of the topic. Additionally, Rudd et al. (2020) advocate for interdisciplinary approaches that engage students in developing skills across diverse subjects, contextualizing climate change within a broader sociological context.

Community: The integration of a local approach in climate change education is evident in multiple studies. For instance, Brumann et al. (2022) highlight the relevance of understanding regional climate change. Jones et al. (2022) emphasize community-building as a central aspect, tied to local culture. Park et al. (2020) showcase students investigating climate change within their local context. Notably, Putland et al. (2021) stress the importance of indigenous knowledge, particularly among Inuit communities, offering a unique perspective on climate adaptation and survival. Additionally, several studies underscore the significance of place-based education, connecting students to their local environment (Khadka et al., 2021; Pappo et al., 2022; Sellmann & Bogner, 2013). Field trips are a valuable part of CCE (Jones et al., 2022; Khadka et al., 2021; Pruneau et al., 2003). These trips offer hands-on experiences that connect students with their environment and foster practical learning.

Reflection: Reflection serves as a crucial tool in enhancing climate literacy. Khadka et al. (2021) demonstrated the effectiveness of self-reflection tools like "score cards" to evaluate individuals' engagement in climate-friendly activities. This self-assessment not only encourages personal responsibility but also empowers learners to recognize their impact on environmental sustainability. Pruneau et al. (2006) revealed the significance of reflective activities, such as maintaining journals, in fostering a process of change awareness. By encouraging students to predict consequences and formulate personal opinions on climate change (Pruneau et al., 2003), reflection fosters a deeper understanding of the complexities associated with environmental challenges.

Affective response: The emotional connection to climate change is fostered through activities that encourage the expression of feelings. Bentz (2020) highlighted how learners' emotional engagement was expressed through stories related to climate change. Affective activities, such as moments of solitude in nature, as explored by Pruneau et al. (2006), provide a safe space for individuals to articulate their emotions. This emotional connection strengthens learners' sense of responsibility and encourages them to engage actively in climate change initiatives.

Discussion: Discussion plays a pivotal role in informed engagement and critical thinking within CCE. Arya and Maul (2016) demonstrated the effectiveness of classroom discussions in evaluating arguments related to climate change issues. Collaborative learning, as observed by Korsager and Slotta (2015), promotes peer collaboration and enriched understanding through dialogue. Engaging in discussions allows students to explore climate change adaptation strategies collectively (Park & Kim, 2020), broadening the scope of their actions and encouraging them to consider diverse perspectives. Gutierrez et al. (2022) highlights the effectiveness of interpersonal discussions about climate change, involving parents and friends, which fosters emotional engagement and creative connections to the topic.

Future orientation: Future orientation is a significant aspect of CCE programs. Brydon-Miller et al. (2022) introduce the "Utopian Phase", enabling participants to envision unconstrained future scenarios, fostering a collective sense of optimism. Levrini et al. (2021) emphasize the development of "future-oriented activities" and "futures thinking" skills. Pruneau et al. (2006) showcase how future education, including forecasts of climate change impacts, aids informed decision-making. Moreover, Pruneau et al. (2003) underline the importance of predicting consequences of climate-related signs

and emissions. These studies collectively highlight the role of future orientation in cultivating proactive attitudes and enabling sustainable contributions.

Global engagement: International collaboration is a prominent feature in CCE programs, as highlighted by various studies. Arya and Maul (2016) underscore cross-classroom exchanges and online connections to engage students globally. Brydon-Miller et al. (2022) emphasize building relationships with international peers. Finally, Korsager and Slotta (2015) stress the value of global peer collaboration. These studies collectively illustrate the importance of international collaboration in enriching the scope and cross-cultural dimensions of CCE programs.

Creative engagement: The integration of art-based approaches in CCE programs is highlighted across various studies, underscoring its potential to engage learners in meaningful ways. For instance, Brydon-Miller et al. (2022) emphasized the use of short dramatic depictions performed as silent plays to engage students in portraying climate change issues. Similarly, Jones et al. (2022) reflected on arts-based climate education exemplars involving collaborative visual representation through drawings, writings, and even costume designing with local waste materials. Rooney-Varga et al. (2014) showcased the CAM Project's phases of preproduction, production, and postproduction, integrating art and media creation into climate education. Moreover, Rudd et al. (2020) explored diverse art forms, including creative writing and game design, to enable students to delve into complex topics such as personal responsibility and the consequences of climate change. These studies collectively demonstrate the efficacy of art-based methods in fostering deeper connections and creative engagement within the realm of climate education.

Challenge perception: Identifying challenges is a crucial aspect essential for effective education. Inquiry-based learning (IBL), as emphasized by Brumann et al. (2022) and Korsager and Slotta (2015), emerges as a potent approach for fostering critical thinking. Levrini et al. (2021) highlight the significance of equipping learners with skills to navigate complexity. Scientific models, exemplified in Park and Kim (2020), aid in comprehending multifaceted climate change causes. Localized exploration, underscored by Park et al. (2020), enhances the recognition of distinct challenges. In summary, this paragraph underscores the importance of recognizing, addressing, and overcoming challenges in CCE through diverse strategies.

Project-based learning: Project-based learning is a dynamic approach within CCE, fostering immersive and practical learning experiences. Several studies provide valuable insights into programs that effectively utilize project-based learning to engage students in climate change issues. For instance, Bentz (2020) showcases the significance of group dialogues in reflection during a 30-day experiment. Park and Kim (2020) exemplify the integration of climate change club projects, enabling students to plan and implement personal or social actions. Pruneau et al. (2006) highlight science-related experiments and collaborative group actions that aim to safeguard climate equilibrium. Flora et al. (2014) exemplify project-based learning through scaled, interactive presentations. These studies collectively underscore the efficacy of project-based learning in nurturing active engagement and deep understanding within the realm of climate change education.

Action-based learning: Action-based learning holds a central place in CCE, as it aims to empower students to take meaningful steps towards addressing climate challenges. Several CCE programs employ innovative strategies to encourage actionable responses. For instance, Bentz (2020) emphasizes the significance of individual commitment by encouraging students to identify and

implement "one small change". Brydon-Miller et al. (2022) fostered action competence through initiatives like a climate action group and the Do One Thing project, where students identified and posted actionable commitments on a Pledge Tree. Jones et al. (2022) highlight hands-on activities that promote learning through lived experience, further enhancing students' potential for meaningful action. Moreover, Park and Kim (2020) orchestrated a multifaceted approach by involving students in planning and executing personal or social actions as part of climate change club projects. Sellmann and Bogner (2013) extend this notion by providing practical workstations, each focusing on specific ecological aspects affected by climate change, encouraging students to engage in practical activities within the garden. These diverse examples underscore the importance of fostering action-oriented learning experiences within CCE, cultivating a generation of proactive individuals prepared to make a positive impact on our planet.

Discussion

Examining the outcomes of this systematic review reveals several significant trends worth highlighting. To begin with, there has been a substantial increase in publications related to CCE programs since the year 2020. This trend mirrors earlier findings identified by Monroe et al. (2019), Nepras et al. (2022), and Rousell & Cutter-Mackenzie-Knowles (2020). This positive evolution suggests a promising trajectory for the field of CCE. A noticeable geographical asymmetry becomes clear. The majority of publications originate from high-income countries, with less representation from lower- and middle-income nations, echoing the findings of previous reviews (Monroe et al., 2019; Nepras et al., 2022; Rousell & Cutter-Mackenzie-Knowles, 2020). This imbalance underscores the urgency of expanding CCE research to encompass a more diverse range of regions and socio-economic contexts, especially since studies like Cordero et al. (2020) highlight the positive long-term impact of CCE on students, such as a decrease of individual carbon emissions and pro-environmental decisions. A significant proportion of the reviewed studies primarily target secondary education, especially at the upper secondary level. While there is some attention given to university-level education and informal learning contexts, the dominance of secondary education is striking. This observation aligns with previous reviews (Monroe et al., 2019; Nepras et al., 2022; Rousell & Cutter-Mackenzie-Knowles, 2020). Notably, starting CCE at an earlier age has been shown to have a more profound impact on later behavioural outcomes (Nepras et al., 2022).

An analysis of the reviewed studies reveals that CCE programs employ innovative methods to engage students. Examples include direct interactions with scientists (Arya & Maul, 2016), online platforms for international collaboration (Arya & Maul, 2016; Brydon-Miller et al., 2022; Korsager & Slotta, 2015), encouraging students to make "one small change" (Bentz, 2020) and integrating art forms like drawing and writing into the curriculum (Jones et al., 2022). These inspiring approaches reflect a growing trend in CCE programs. Fourteen predominant themes emerge from the review, a more extensive categorization than many previous studies. The bicycle model, proposed by Tolppanen et al. (2019), aligns well with these findings due to its holistic nature. This model encompasses interconnected components related to various aspects of CCE, including knowledge, values, motivation, future orientation, emotions, action, and operational barriers. These themes provide a comprehensive overview of the diverse topics within climate change education. The findings can also be related to the four components of effective climate change programs identified by Monroe et al. (2019): deliberative discussions, interaction with scientists, addressing misconceptions, and implementing projects. While addressing misconceptions is not explicitly mentioned in this review, it falls under the broader category of "discussion."

Past studies have reported a disproportionate focus on climate change knowledge at the expense of affective dimensions like emotional responses and community dynamics (Rousell & Cutter-Mackenzie-Knowles, 2020; Wynes & Nicholas, 2019). While a similar trend is observed in this review, the disproportion is not as noticeable. Climate literacy is a predominant theme but is closely followed by other topics. This balanced emphasis could be attributed to the inclusion of the publications of the last few years whereas earlier reviews included more outdated climate change educational programs. More recent programs might have incorporated the importance of personal relevance and learner engagement. Encouragingly, participatory, interdisciplinary, and creative approaches to climate change education are increasingly prevalent in recent research. Engagement and behavioural aspects have gained prominence, although the emotional dimension remains a relatively smaller topic, suggesting room for growth in this area.

Several limitations inherent to this study deserve attention. The overrepresentation of research from the United States and the restriction to English-language publications may introduce a bias, potentially limiting the generalizability of the findings to other regions and linguistic contexts. Furthermore, the presence of studies funded by specific entities, such as NASA or specialized curriculum initiatives, could introduce a bias towards technology-focused approaches. Additionally, the review process focused on quantifying the occurrence of specific topics within the included studies, rather than delving into the depth or significance of each topic within individual programs. This approach might not fully capture the relative emphasis of each topic within the broader context of CCE programs. While efforts were made to minimize these biases, they should be considered when interpreting the findings. Lastly, as with any systematic review, there is a possibility that some relevant studies were missed during the search and selection phases, potentially affecting the completeness of the evidence base.

The insights from my review can assist policymakers in making informed decisions and designing effective strategies to enhance CCE programs in secondary and tertiary education. Teacher training programs can equip future educators with innovative approaches and best practices in CCE, better preparing them to empower young individuals with the skills necessary for climate change mitigation and adaptation. Furthermore, stakeholders engaged in the implementation of TVET programs can benefit from this research by gaining a deeper understanding of the impact and potential of their initiatives. My review contributes to the field of CCE research by providing recent insights into the demographics and prevalent topics of CCE programs, with a particular focus on secondary and tertiary education. These findings can be compared to those of review studies that concentrate on different age groups. Additionally, my research contributes to the testing of frameworks designed for CCE. My holistic perspective, covering a wide range of topics within CCE, offers a comprehensive understanding of the field.

Conclusion

In summary, this study highlights the expanding landscape of CCE, characterized by a growing interest, although with an uneven global distribution. The need to broaden research efforts to low-and-medium-income countries becomes increasingly evident. While knowledge-based content remains a cornerstone of CCE programs, there is a gradual increase in attention to attitudes, engagement, and behavioural dimensions. However, there remains a notable lack of emphasis on affective components in CCE programs. Future programs should incorporate a greater focus on affective components, particularly for children, given that 70% of them face extremely high climate risk (United Nations Children's Fund, 2021). It is essential to prepare them for active participation in climate mitigation and

adaptation, equipping them with climate literacy for behavioural change and collective action, fostering skills for a 'just transition' to a green economy, and building adaptive capacity (Ehlers et al., 2022).

This study serves as a foundation for further research, enabling in-depth exploration of CCE across diverse educational settings. Future research should particularly concentrate on various forms of education, including the unique context of technical and vocational education. Moreover, there should be a concerted effort to report on CCE programs in different parts of the world, not limited to high-income countries.

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Attachments

Attachment 1.

Table of all publications included in the review

Year	Title	Author
2013	ICT Challenges and Issues in Climate Change Education	Alexandru, Adriana; Ianculescu, Marilen
2016	The Building of Knowledge, Language, and Decision-Making about Climate Change Science: A Cross-National Program for Secondary Students	Arya, Diana; Maul, Andrew
2020	Learning about climate change in, with and through art	Bentz, Julia
2015	Climate Change Education: The Role of Pre-Tertiary Science Curricula in Ghana	Boakye, Cecilia
2016	Developing a learning progression for sea level rise, a major impact of climate change	Breslyn, Wayne; McGinnis, J. Randy; Mc
2022	Inquiry-Based Learning on Climate Change in Upper Secondary Education: A Design-Based Approach	Brumann, Sebastian; Ohl, Ulrike; Schulz
2022	Creating a Virtual Space for Collaborative Project Planning Using the Future Creating Workshop Process: Building the Global Climate Change ...	Brydon-Miller, Mary; Williams, Bronwyn
2019	Teaching anthropogenic global climate change (AGCC) using climate models	Bush, Drew; Sieber, Renee; Chandler, M
2014	Using Remote Sensing and Geospatial Technology for Climate Change Education	Cox, Helen; Kelly, Kimberle; Yetter, Laur
2014	Evaluation of a national high school entertainment education program: The Alliance for Climate Education	Flora, June; Saphir, Melissa; Lappé, Mat
2022	What Effective Design Strategies Do Rural, Underserved Students in STEM Clubs Value While Learning about Climate Change?	Gutierrez, Kristie S.; Blanchard, Margare
2022	Climate Change and Sustainability Education in India and the Place for Arts-Based Practice: Reflections from East Kolkata Wetlands	Jones, Verity; Mitra, Saptarshi; Gupta, N
2015	Remediating misconception on climate change among secondary school students in Malaysia	Karpudewan, Mageswary; Roth, Wolff-I
2021	Unpacking the Power of Place-Based Education in Climate Change Communication	Khadka, Akriti; Li, Christine Jie; Stanis, S
2015	International Peer Collaboration to Learn about Global Climate Changes	Korsager, Majken; Slotta, James D.
2021	Recognition and operationalization of Future-Scaffolding Skills: Results from an empirical study of a teaching-learning module on climate cha...	Levrini, Olivia; Tasquier, Giulia; Barelli, El
2022	Enhancing Climate Change Education through Links to Agriculture	Pappo, Emily; Wilson, Chris; Flory, S. Lu
2020	The Impact of Project Activities on the Cultivation of Ecological Citizenship in a High School Climate Change Club	Park, Woo-Yong; Kim, Chan-Jong
2020	The Virtual Field Trip: Investigating How to Optimize Immersive Virtual Learning in Climate Change Education	Petersen, Gustav B.; Klingenberg, Sara;
2021	Climate Literacy-Imperative Competencies for Tomorrow's Engineers	Powers, Susan E.; DeWaters, Jan E.; Dha
2006	The Process of Change Experimented by Teachers and Students when Voluntarily Trying Environmental Behaviors	Pruneau, Diane; Doyon, Andre; Langis, .
2003	Experimentation with a Socio-Constructivist Process for Climate Change Education	Pruneau, Diane; Gravel, Helene; Bourque
2021	Including the Ocean in Formal K-12 Climate Education: Assessment of a Lesson for Middle and High School Students	Putland, Jennifer; Hoeberechts, Maia; Pe
2014	Student Media Production to Meet Challenges in Climate Change Science Education	Rooney-Varga, Juliette N.; Brisk, Angelic
2020	You and CO2: a Public Engagement Study to Engage Secondary School Students with the Issue of Climate Change	Rudd, Jennifer A.; Horry, Ruth; Skains, R
2013	Climate Change Education: Quantitatively Assessing the Impact of a Botanical Garden as an Informal Learning Environment	Sellmann, Daniela; Bogner, Franz X.

Attachment 2.

Codebook systematic review

country
Canada
Denmark
Germany
Ghana
Italy, Finland, Iceland, Ireland
Korea
Malaysia
Norway
Portugal
The Philippines, South Africa, Austria
UK
UK, India
UK, Spain, Romania, Italy, Hungary and France
USA
USA, China, New Zealand and Norway
goals
behavior
communication
engage
future orientation
hope
interest
knowledge
nothing to do with CCE
creating international network
information literacy
responsibility
wrong_about goals study instead of program
making learning interesting
outcomes
program setting
age
higher secondary
informal
Lower secondary
university
TVET
topics
action based
affective response
challenge perception
inquiry-based learning
Climate literacy
community

field trips
indigenous knowledge
creative engagement
discussion
future orientation
Global engagement
multidisciplinarity
sociology
project based
experiments
reflection
Science
Technology