Environment and Social Psychology (2025) Volume 10 Issue 10 ISSN: 2424-8975 (O)
doi: 10.59429/esp.v10i10.4015 2424-7979 (P)

RESEARCH ARTICLE

From awareness to action: Strengthening climate change education for a sustainable future

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ABSTRACT

SDG 13 on climate action, Climate Change Education (CCE), has appeared to be a crucial component in addressing global environmental challenges. Despite its recognised importance, CCE remains underutilised as a strategic resource in mitigating and adapting to climate change. This study examines the factors contributing to the underutilisation of CCE in schools and universities, and explores solutions for its implementation. The methodology employs a systematic literature review approach using major academic databases, including Web of Science, Scopus, and Dimensions. Through screening of titles and abstracts, 22 relevant articles published within the last 10 years were selected. The research utilises both AI-assisted text mining techniques and human expertise for data extraction and synthesis. Quality assessment was conducted using AMSTAR (A Measurement Tool to Assess Systematic Reviews) to ensure methodological rigor in evaluating complex interdisciplinary topics.

Keywords: Climate Change Education (CCE); Sustainable Development Goal (SDG); teaching and learning; youth's role; climate urgency

1. Introduction

1.1. Background of the study

The United Nations introduced SDGs in 2015 with the aim of overcoming various challenges faced by people all over the world. The 17 interconnected SDGs, also known as Global Goals, require initiatives to protect the planet, as well as to end poverty, to achieve peace and prosperity among the nations. This paper focuses on one of the SDGs, which is SDG 13, climate action. It has three main targets including adaptive capacity and strengthening flexibility to climate-related hazards, increase awareness and advocate on education in climate change along with incorporating the climate change measures into national policies[1]. Malaysia is also playing its role to achieve these targets. In 2016, Malaysia acknowledged to the Paris Agreement, to keep the global rise between 1.5 to 2°C. The agreement provided a legal framework for

ARTICLE INFO
Received: 5 October 2025 | Accepted: 22 October 2025 | Available online: 30 October 2025

CITATION
Olaybal DL, LEE KH, Yeo HQ, et al. From awareness to action: Strengthening climate change education for a sustainable future. *Environment and Social Psychology* 2025; 10(10): 4015. doi: 10.59429/esp.v10i10.4015

implementing SDG 13 through transparency, technology transfer and financing.

In year 2020, four years later, the Malaysia Climate Change Action Council was established and chaired by Tan Sri Muhyiddin Yassin, the former Prime Minister. Until today, the council still focuses on three key areas, which are policy making, development planning and implementation, and guidance and reporting[2]. Based on these areas, it is undoubtedly that education plays a crucial role to address the climate change through SDG 13, particularly in raising awareness, improving education, and institutional capacity for mitigating, adapting climate change, impact reduction and early warning[3].

SDG 13 is at the heart of global climate governance as it links national policies to mitigation, adaptation and resilience objectives under the Paris Agreement. Recent studies on climate also stress the importance of including cross-sector information in climate action, since risks related to climate are closely linked with urban systems, public health and ecological stability (e.g., carbon balance, thermal environment, and medical effects). These global linkages are also a clear rationale for which CCE should be elevated as priority research in SDG 13, since education is the most direct means to increase public knowledge about climate and support informed community engagement with climate policy implementation.

Education is considered as both ethical and cost-effective approach when dealing with climate change. The tremendous effect when individuals share their climate knowledge to their families and the people around them proven to be an effective approach to implement. The knowledge shared enables families and communities to spread the information gathered beyond the classroom, which empowers them to participate more effectively in civil society and be involved in local decision-making[4]. In the context of Climate Change Education (CCE), this dissemination of knowledge fosters environmental awareness, promotes sustainable practices, and encourages proactive engagement in climate-related policies and initiatives at both local and global levels. CCE refers to educational processes with the aim to enhance how education systems prepare for and respond to the challenges of climate change.

According a study conducted by Ramos de Robles and team, they asserted that the educational processes require longer-term and instant responses that view at ways on improving the understanding of factors and consequences of climate change for learners, along with the solutions to overcome it[5]. Interdisciplinary filed of ecological, political, ethical, social and scientific field of climate change must be approached for CCE. Additionally, CCE can significantly build adaptive and resilience capacity in communities to foster hope as well as constructive responses rather than despair[4], also lead to reductions in carbon emissions[6]. Of utmost importance, CCE prepares the future generation with the drive and expertise to engage actively in climate solutions.

1.2. Statement of the problem

According to Muccione and team, CCE still maintains as an underutilised tool for climate change mitigation and adoption despite on its many benefits[7]. Thus, there is an urgent need to integrate CCE into curricula and adopt a proactive approach which place education as the key driver of sustainability efforts. Although educators are highly aware of these climate issues, barriers in transforming this knowledge into practice is the main barrier that often occurred to them which led to a significant gap between action and awareness. Therefore, this paper aimed to bridge the gap by investigating the factors and challenges that hinder the implementation of CCE in educational institutions and discovering effective solutions to ensure a successful integration.

1.3. Research questions

The research questions leading the study are:

a) What are the factors that Climate Change Education (CCE) is being underutilised in schools and universities?

b) What are the solutions in optimising the implementation of Climate Change Education (CCE) in schools and universities?

This paper aimed to study the gaps between the awareness and implementation of CCE in educational institutions. The education sector remains underutilised as a strategic platform for climate change mitigation and adaptation, despite being recognised as important for addressing climate challenges. The study also focuses on the need to develop coherent solutions for the implementation of CCE, as many countries still lack these. Additionally, educators in schools and universities often face barriers in having flexibility by adding themes that are relevant to climate change in the curriculum. Understanding the challenges faced by these educators and identifying the solutions is a must as the implementation via educational platforms is not costly and more effective.

2. Methodology

2.1. Search strategy

This study was conducted to examine the barriers and solutions of the implementation of Climate Change Education (CCE) in schools and universities. To conduct a comprehensive search for articles and relevant databases, the researchers had included several key components. The search was done by utilising major academic databases like Web of Science, Scopus and Dimensions. Terms like “climate change” or “global warming” with certain education-related terms, “teach” and “education” were combined as keywords. Researchers also filtered the titles and abstracts in a systematic way, omitting those duplicate findings that were not relevant. Furthermore, to capture the contemporary challenges and solutions, a clear timeframe was defined. Only articles that were published 10 years and below and relevant to both formal and informal education situations were utilised in this research as it were considered as CCE extends beyond traditional classroom settings.

2.2. Timeline

As the research objective of this study is to investigate the underutilisation of CCE along with its implementation, the timeline spanned from 2016 to 2025 as this is the period that would align with the significant global climate education initiatives and increasing awareness of Malaysia’s CCE implementation. The starting point of 2016 aligned with the Paris Agreement’s call for improved climate change education. Throughout these years, the researchers noticed that there is an increased recognition in the education roles to address the climate changes even the implementation was inconsistent. Moving on, the period extend to year 2025, to capture the recent developments of CCE integration efforts. These developments including policy changes and innovative teaching approaches. Based on this timeline, it allows researchers to synthesise the challenges and solutions in implementing CCE which also integrating current views on the transformative education practices.

2.3. Inclusion and exclusion criteria

To ensure the findings are relevant to the research question, the inclusion and exclusion criteria were identified when the studies are being selected. Inclusion criteria of this study pinpoint on clear documentation of abstracts and hyperlink addresses in peer-reviewed articles. Besides, this study also

covered both formal and informal education settings and consisted of perspectives from several stakeholders, such as – students, educators, administrators. Additionally, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was also included in the review process[7]. According to **Figure 1**, PRISMA guided researchers to conduct the review step by step for choosing relevant data.

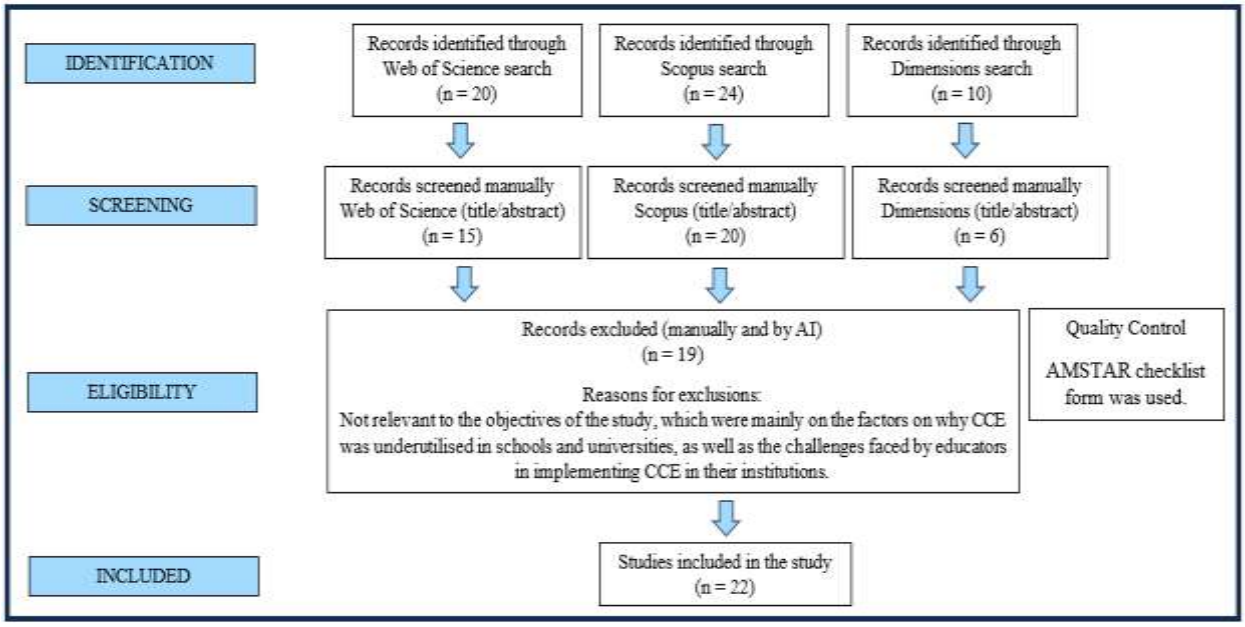


Figure 1. Adapted PRISMA Flow Diagram.

Those articles with no abstracts of hyperlink address and duplicate publications were removed based on the exclusion criteria. Articles were excluded if they: (i) focused solely on climate science and did not discuss information on educational impacts, (ii) tested public awareness but not schools or universities, or (iii) lacked empirical or conceptual value added to CCE implementation. To ensure the relevancy of the chosen articles in contemporary issues and solutions, specific timeframe of publications was assured by the researchers. Other than this, papers that solely focus on technical climate science without components being discussed in the education field were omitted too because a combined interdisciplinary point of view in scientific knowledge with economic, social and political purpose was the primary requirement in investigating CCE.

2.4. Data extraction

The data extraction for this study was completed by suing Artificial Intelligence (AI) tools and human expertise to acquire optimal results. Out of all the chosen articles, the researchers have shortlisted 22 relevant articles on implementing CCE in education field. Text mining approach has supported the researchers to automate the extraction of information from chosen articles[7]. Therefore, the researchers could pay more attention on ensuring the contextual understanding and accuracy of those articles. Moving on, the researchers organised the data systematically based on the research question of this study. The researchers also considered those author's background to ensure the findings were supported with valid and reliable sources. The text-mining approach relied on TF-IDF for keyword extraction and Latent Dirichlet Allocation (LDA) for automatic topic modelling. Scores of coherences and manual validation were applied to verify extracted themes.

Semantic analysis, text summarisation techniques and topic modelling were other techniques the researchers utilised to extract the data. These techniques supported researchers to synthesise the key findings

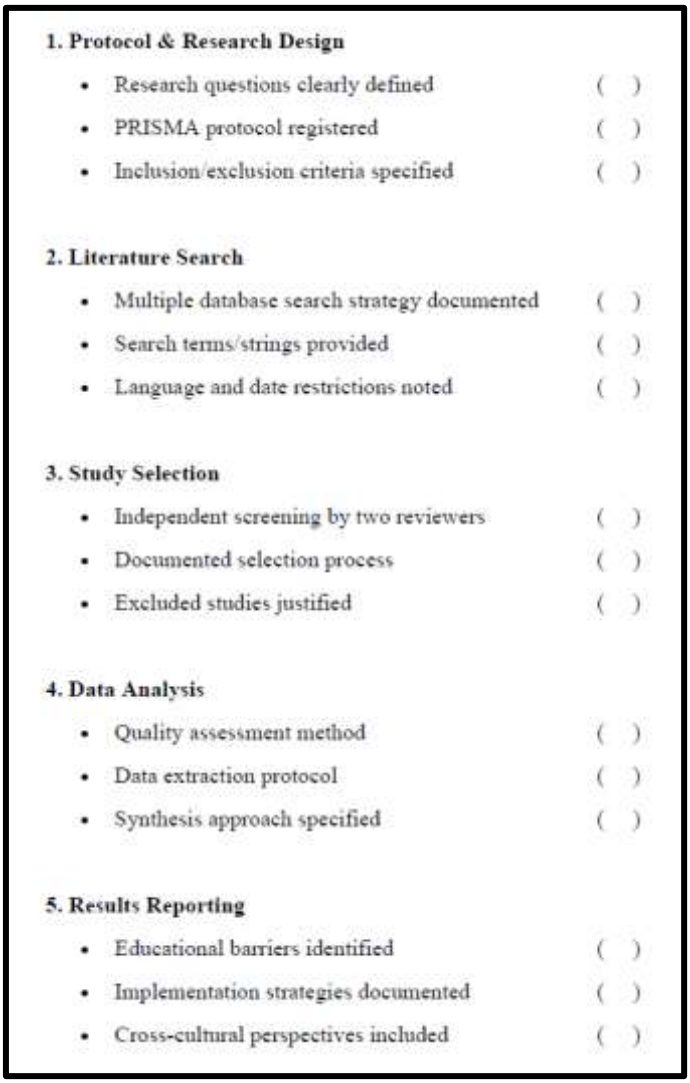
from all chosen articles easily and to maximise the efficacy, the combination of human-AI approach was utilised too which at the same time, also maintaining the quality of this research content.

2.5. Data synthesis

Conducting narrative synthesis is the primary way to evaluate the data to get the results. The researchers summarised the categorised points extracted from the gathered articles using text mining techniques that enabled the improvement of human capacity to handle unstructured text data massively[3]. The text-mining was executed in three steps: (1) discovering repeated keywords to define shared barriers, (2) use of LDA topic model to cluster issues into specific themes, and (3) performing semantic clustering to match themes with the research questions. The focus was clear. They only looked at how different studies fit together, highlighting the factors on why CCE was underutilised in schools and universities, and what were the challenges faced by the educators to successfully implement it in their institutions. Apart from that, the researchers also explored relationships between the findings and the research questions, making sure the relevance before reaching to the discussions of the study.

2.6. Study quality assessment

Among 54 articles, only 22 relevant articles were analysed and synthesised in the findings. The researchers found out that AMSTAR (A Measurement Tool to Assess Systematic Reviews) was suitable for a systematic literature review on the implementation of CCE. There are several reasons why the researchers decided on this. The reasons were, AMSTAR could evaluate methodological quality of reviews[8], allowing thorough comprehensive assessment of the study, specifically on why CCE was underutilised, as it could assess complex barriers across educational systems. Besides, AMSTAR could handle complex interdisciplinary topics[9], which was an advantage since CCE implementation involved multiple stakeholders and disciplines. This study also aimed to look into the challenges of the implementation of CCE in schools and universities. Thus, AMSTAR's systematic approach enabled evaluation of successful educational interventions and practices[7]. This included innovative teaching methods and curriculum strategies, which directly connected to identifying practical solutions for improving CCE adoption in schools and universities. The AMSTAR checklist form[10] (**Figure 2**) to prove the validity and reliability of this study.



1. Protocol & Research Design

- Research questions clearly defined ( )
- PRISMA protocol registered ( )
- Inclusion/exclusion criteria specified ( )

2. Literature Search

- Multiple database search strategy documented ( )
- Search terms/strings provided ( )
- Language and date restrictions noted ( )

3. Study Selection

- Independent screening by two reviewers ( )
- Documented selection process ( )
- Excluded studies justified ( )

4. Data Analysis

- Quality assessment method ( )
- Data extraction protocol ( )
- Synthesis approach specified ( )

5. Results Reporting

- Educational barriers identified ( )
- Implementation strategies documented ( )
- Cross-cultural perspectives included ( )

Figure 2. Adapted AMSTAR Checklist Form.

3. Findings and discussion

After utilising the inclusion criterion for selection, the final 22 studies (**Table 1**) were selected for review.

Table 1. Summary of Selected Studies on CCE.

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
1	Brown, G. T. L. (2017)[11]	CCE Challenge (Assessment)	Assessment of Student Achievement	Literature Review	To explore the challenges and strategies in modern educational assessments.	Identified key challenges in educational assessments and proposed strategies for improvement.
2	Gleeson, E. M., & Morrissey, J. (2024)[12]	CCE Challenge	Climate Change Education in Ireland: A Crisis in Need of a Meaningful Cross-Curricular	Mixed-method (questionnaire survey, interview)	To examine primary school teachers' approaches to climate change education (CCE)	CCE Barriers: Curriculum, teacher knowledge, pedagogical approaches and content, continuing professional development and influences outside the

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
			Response?		and the factors that influence this through analysis of data collected in the Irish context.	education system. Suggestion: Curriculum reform and redevelopment in the Irish context, with implications for education regimes internationally.
3	Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R. E., Mayall, E. E., Wray, B., Mellor, C., & Van Susteren, L. (2021)[13]	CCE Challenge (Youth's worry)	Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey	Quantitative (10k children & youths in survey from 10 countries)	To investigate climate anxiety in children and young people globally and its relationship with perceived government response	Climate anxiety and dissatisfaction with government responses are widespread in children and young people in countries across the world and impact their daily functioning. There is an urgent need for further research into the emotional impact of climate change on children and young people and for governments to validate their distress by taking urgent action on climate change.
4	Baldwin, C., Pickering, G., & Dale, G. (2022)[14]	CCE Challenge	Knowledge and self-efficacy of youth to take action on climate change	Quantitative (425 youths in survey form)	Investigate attitudes of youth living in an Australian Biosphere Reserve to identify their understanding of CC causes, impact, and mitigation measures, as well as their feelings of self-efficacy and hope.	Inform communication and education interventions to mobilise youth to respond to the global climate crisis
5	Sarrasin, O., Von Roten, F. C., & Butera, F. (2022).[15]	CCE Challenge	Who's to Act? Perceptions of Intergenerational Obligation and Pro-Environmental Behaviours among Youth	Quantitative [high school (n = 639) and bachelor (n = 1509) students in French-speaking Switzerland]	To incorporate perceptions of self-efficacy, feelings of external control, and intergenerational obligation (i.e., believing that all generations should act) into the Value–Belief–Norm model.	Educational programs on climate change should integrate intergenerational components.
6	Bryan, C. J., Yeager, D. S., Hinojosa, C. P., Chabot, A., Bergen, H., Kawamura, M., &	CCE Challenge (Youth's mind)	Harnessing adolescent values to motivate healthier eating	Quantitative	The present research uses a rigorous randomized trial to evaluate an approach that aligns healthy behavior with	Public health interventions for adolescents may be more effective when they harness the motivational power of that group's existing strongly held values.

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
	Steubing, F. (2016)[16]				values about which adolescents already care: feeling like a socially conscious, autonomous person worthy of approval from one's peers.	
7	Galla, B. M., Choukas-Bradley, S., Fiore, H. M., & Esposito, M. V. (2021)[17]	CCE Challenge (Youth's mind)	Values-Alignment messaging boosts adolescents' motivation to control social media use	Quantitative	To investigate behaviour change on an outcome that is highly relevant to adolescent development: social media use (SMU).	Leveraging adolescents' drives to act independently from adult control and to serve a larger societal purpose, two highly rewarding adolescent values, may be one approach for instilling a motivation for self-regulating social media use.
8	Waldron F., Mallon B., Barry M., & Martinez Sainz G. (2020)[18]	CCE Challenge	Climate Change Education in Ireland: Emerging Practice in a Context of Resistance	Qualitative	To examine the demands faced by teachers as they address the climate crisis and considers how their professional agency is shaped by their surrounding environments	Provide a framework for educators to support the knowledge, understanding and collective action of children, young people and wider society.
9	Subina Beegum, S., & Bindu, T. V. (2022)[19]	CCE Challenge	Reflection on Job Satisfaction and Job Stress of Primary School Teachers in Kerala during COVID-19	Survey Method	To reflect on job satisfaction and job stress during the COVID-19 pandemic.	Teachers experienced increased job stress and varied job satisfaction levels during the pandemic.
10	Vyas, R. (2020)[20]	CCE Challenge	Occupational Stress, Anxiety and Job-Satisfaction among Female Government and Private School Teachers.	Quantitative Descriptive Research	To assess occupational stress, anxiety, and job satisfaction among female teachers.	Government teachers have better job satisfaction and less occupational stress than private school teachers.
11	Eres, F., & Atanasoska, T. (2011)[21]	CCE Challenge (Occupational Health)	Occupational Stress of Teachers: A Comparative Study between Turkey and Macedonia	Comparative Study	To compare occupational stress levels among teachers in Turkey and Macedonia.	Teachers in Turkey reported higher stress levels compared to those in Macedonia; identified common stressors.
12	Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves,	CCE Optimization methods	Identifying effective climate change education strategies: a systematic review	Review	To increase interest in climate change education and the growing recognition of the	Two themes were identified that are common to most environmental education: (1) focusing on personally relevant and meaningful

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
	W. A. (2017)[22]		of the research		challenges	information and (2) using active and engaging teaching methods. Four themes specific to issues such as climate change were also generated: (1) engaging in deliberative discussions, (2) interacting with scientists, (3) addressing misconceptions, and (4) implementing school or community projects. Suggestions for addressing controversial topics like climate change are offered.
13	Walsh, M., Matsumura, L. C., Zook-Howell, D., Correnti, R., & Bickel, D. D. (2019)[23]	CCE Optimization methods (Teachers' Role)	Video-based literacy coaching to develop teachers' professional vision for dialogic classroom text discussions	Research study	To explore how 4th and 5th grade teachers' reflective practice developed as they participated in a remote video-based coaching intervention to implement dialogic classroom text discussions.	Findings suggest teachers became more focused on the connection between their discussion moves and students' thinking in video, and their reasoning about these interactions became more interpretive and in-depth over time. Implications for research on how teachers learn dialogic pedagogies are discussed.
14	MacKay, M., Parlee, B., & Karsgaard, C. (2020)[24]	CCE Optimization methods (Indigenous Youth's Roles)	Youth Engagement in Climate Change Action: Case Study on Indigenous Youth at COP24	Qualitative	To share the outcomes of research with Indigenous youth (along with family and teachers) from the Mackenzie River Basin who attended COP24 to determine the value of their experience	Key insights related to the value of a global experience; multiple youth presentations at COP24 were heard by hundreds of people who sought to learn more from youth about their experience of climate change. Additional insights were gathered about the importance of family and community (i.e., webs of support); social networks were seen as key to the success of youth who participated in the event and contributed to youth learning and leadership development.
15	Karsgaard, C., & Shultz, L. (2022)[25]	CCE Optimization methods (Youth's voice)	Youth Movements and Climate Change Education for Justice	Research study	To adequately respond to the global youth climate strikes and Indigenous movements	A open space for climate change education grounded in relationality and kinship founded in Indigenous relational ontologies, whereby humans are not the centre of climate learning and decision-making but are inherent within webs of relations among all things.
16	McCowan, T. (2020)[26]	CCE Optimization	*The Impact of Universities on*	Qualitative	To explore a framework for	The framework serves as an analytical tool to identify

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
		methods (university's role)	*Climate Change: A Theoretical Framework*		understanding the impact of universities on climate change	the trajectories of impact already in evidence, but also presents normative implications for the role of higher education institutions in addressing the current climate crisis.
17	Haugestad, C. A., Skauge, A. D., Kunst, J. R., & Power, S. A. (2021)[27]	CCE Optimization methods (Youth's involvement)	Why do youth participate in climate activism? A mixed-methods investigation of the #FridaysForFuture climate protests	Mixed mode	To investigate people's motivations for joining the movement in the privileged yet paradoxical context of Norway – a country that has gathered most of its wealth through oil production	The understanding of global environmental movements from the perspective of participants, who are both structurally responsible for the crisis and will experience most of its consequences themselves, can contribute to the broader discussion on facilitating climate action within privileged contexts.
18	Rousell, D., & Cutter-Mackenzie-Knowles, A. (2019)[28]	CCE Optimization methods (Youth's involvement)	A systematic review of climate change education: giving children and young people a 'voice' and a 'hand' in redressing climate change	Qualitative (Systematic Review)	To analyse existing literature from 1993 to 2014 regarding climate change education for children and young people, with the aim of identifying key areas for further research	The review 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
19	Forster, P. M., Smith, C. J., Walsh, T., Lamb, W. F., Lamboll, R., Hauser, M., Ribes, A., Rosen, D., Gillett, N., Palmer, M. D., Rogelj, J., Von Schuckmann, K., Seneviratne, S. I., Trewin, B., Zhang, X., Allen, M., Andrew, R., Birt, A., Borger, A., . . . Zhai, P. (2023)[29]	CCE Optimization methods (Indicators Data)	Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence	Quantitative	To make annually updated reliable global climate indicators available in the public domain	This high rate of warming is caused by a combination of greenhouse gas emissions being at an all-time high of 54 ± 5.3 $GtCO_2e$ over the last decade, as well as reductions in the strength of aerosol cooling. Despite this, there is evidence that increases in greenhouse gas emissions have slowed, and depending on societal choices, a continued series of these annual updates over the critical 2020s decade could track a change of direction for human influence on climate.
20	Frumkin, H. (2016)[30]	CCE Optimization methods (Environmental Health)	Environmental Health: From Global to Local, 3rd Edition	Qualitative	To provide a multi-faceted view of the topic, and how it affects different	Lay out the facts, makes the connections, and demonstrates the importance of these crucial issues to human health and

SR	Authors	CCE-related discipline	Topic/ Themes	Method	Objective	Key Findings
					regions, populations, and professions	well-being, both on a global scale, and in our homes, workplaces, and neighbourhoods
21	Ennes, M., Lawson, D. F., Stevenson, K. T., Peterson, M. N., & Jones, M. G. (2021)[31]	CCE Optimization methods (Professional Development)	It's about time: perceived barriers to in-service teacher climate change professional development	Quantitative	To understand the perceived barriers to participating in Climate Change Professional Development (CCPD)	Rather than developing unique strategies, existing best practices in teacher professional development can be used to support CCPD opportunities. Additional recommendations include thinking creatively about how to create time for teachers to attend and making the professional development directly relevant to teacher's local contexts
22	Grapsas, S., Becht, A. I., & Thomaes, S. (2023)[32]	CCE Optimization methods (Youth's perspective)	Self-focused value profiles relate to climate change scepticism in young adolescents.	Quantitative	To examine the links between basic values and climate change scepticism in young adolescents from three culturally, socially, and politically diverse countries	The early emerging climate change scepticism is linked to value profiles that promote self-interest over collective welfare. These findings suggest opportunity for intervention in early adolescence, when adolescents' budding values and views on polarized topics such as climate change may be relatively malleable.

Table 1. (*Continued*)

3.1. The challenges of CCE underutilisation in schools and universities

Continuous and Comprehensive Evaluation (CCE) is an educational assessment methodology that is based on obtaining a full picture of a student's development and learning which heavily emphasise high-stakes testing[11]. By creating more space for positive learning experiences, CCE is meant to engage students to take ownership of their learning, and promotes critical thinking skills, which is being extended beyond rote learning. Formal education settings are always the focus of CCE activities. The current methods occasionally lead to knowledge gaps in the causes of climate change, global warming, and the greenhouse effect, even in official education along with the sociocultural background of the learners. People's pre-existing views and cultural perceptions can occasionally conflict with scientific knowledge and technical narratives around climate change.

While beneficial, CCE has not been utilised widely, primarily due to several implementation challenges at the college and university level. Among these problems are stakeholder ignorance or knowledge of CCE, opposition to mandated conventional evaluations, insufficient adaptation training for teachers to carry out assessments, and insufficient resources. Also, the diverse learning needs and style of students create more challenges for CCE pedagogy and limitations of infrastructure to effectively utilise CCE assessments. Educators must embrace creative learning techniques to stay up with the rapidly evolving field of climate

change education. Students must comprehend the complexities of climate change, including both its natural features and the associated socioeconomic issues.

Most instructors polled (54%) disagreed that the curriculum offers precise instructions on what CCE should include, according to Iris's research. Educators believe this is challenging because of the curriculum's extreme density. Furthermore, the incorporation of CCE is overshadowed by the educational system's strong emphasis on literacy and numeracy. Given that English and math have standardised assessments, unlike subjects like climate change, many educators feel under pressure to give priority to these essential disciplines. Educator's opinions on the relevance of climate change in the curriculum may be influenced by this perceived lack of significance. Even though many educators seem to be confident in their knowledge of climate change, when questioned, they frequently show lack of comprehension, especially when it comes to ideas like climate justice. If educator's own knowledge is weak, they run the risk of giving students selected or erroneous information.

Climate change is both dramatic and illuminating because it draws attention to the substantial impacts that our individual and collective actions have on the environment. However, many students have climate anxiety, which leaves them feeling overwhelmed and uncertain about how they can contribute[13]. If there are unclear routes to action, this dread may lead to disengagement instead of inspiration. Converting attitudes into pro-environmental behaviour will be another hurdle when implementing CCE in educational institutions. Most of the time, a shift in perspective is accompanied by life experiences, awareness, and the readiness to start the process of becoming active. Some teenagers might not be motivated to act because they believe they cannot make a significant contribution to climate change solutions[14,15]. The "sustainability motive-alignment hypothesis" posits that teenagers who perceive pro-environmental behaviour as being in line with their primary motivations such as autonomy and peer status, will be more inclined to act in its favour. Converting teenagers' perceptions of pro-environmental behaviour from a chore to an activity that is in line with their core values is a problem for CCE[16,17].

Other educational institutions are working to incorporate climate education, but many still encounter obstacles like a curriculum that is too demanding and a shortage of climate science teacher preparation[18]. The institution has the right to desire to address these challenges for the betterment of the educational experience to improve student outcomes or student performance through assessments. By addressing these challenges to the implementation of CCE, educators and stakeholders in educational institution can better implement and utilise CCE for the inclusion of effective educational experiences that will prepare students to navigate the complexities of contemporary life. Among the challenges of CCE underutilisation in educational institutions are:

1. Inadequate Training of Instructors

It is conceivable that many educators have had insufficient training to use CCE effectively. If individuals have not acquired this training, there could be misunderstandings regarding the concepts and procedures of CCE, leading irregular use. For example, is teachers who get very uncomfortable when attempting major and continued assessments. This may make it more difficult to provide students with meaningful feedback and support that is helpful.

2. Resistant to Changes in Traditional Evaluation Methods

Many teachers and institutes have the habit of adhering to the usual methods of assessments, such as standardised tests or final exams. Workload, parental interference in student assessments, and balancing household responsibilities (especially for female teachers) contributed to stress[19]. Their reluctance to change their habits might be rooted in beliefs that certain practices elicit greater credibility or trust. Consequently,

you may encounter resistance to adopting CCE strategies, which are using a different way and means of assessment.

3. Restrictions of Resources

However, aligning CCE properly usually requires investment in additional time, material, and human resources. Budget constraints may limit organisation's ability to invest in the infrastructure, tools, and training essential for implementing CCE. This can cause trouble in regular and effective utilisation of CCE methods due to lack of resources.

4. Constraints on Time

It might be a little difficult for the teachers to continuously evaluate and keep an input for a proper execution of CCE throughout the cycle. Teachers might have too much weight placed on their shoulders with regards to planning assessments and providing feedback, on top of the already difficult job of planning lessons. Sometimes, they will do assessments that are of lesser significance than initially thought. CCE could be implemented as a process without periodic assessment and feedback. Female teachers in private schools faced more stress than their government counterparts[20].

5. Stakeholders Lack of Knowledge

Some stakeholders, like parents, students, and administrators of schools, might not necessarily know about CCE. Or they could be unaware or unclear about its purpose. Awareness among stakeholders regarding the relevance or advantage of CCE implementation may fuel opposition to CCE. Turkish teachers had mild stress, while Macedonian teachers had moderate stress[21].

6. Diverse Student Needs

The needs, skills, and styles of students are greatly varied. CCE can address lack of consistency or buy-in by emphasising a more individualised style of assessment[11]. It may, however, be inefficient for educators to create assessments that meet consideration for each individual student, and an absence in this variation may create unintended consequences for the use of CCE and beliefs students have or perceive that they do not have appropriate support.

7. Insufficient Infrastructure to Support the Delivery of CCE

Effective CCE requires a supportive infrastructure that consists of technology, assessment tools, and a data management system, and many colleges and universities may not have the infrastructure necessary to deliver CCE successfully. This could vary from lacking a method to examine assessment data guiding use of facts for teaching decisions to having limited access to digital tools for monitoring student progress.

3.2. The ways on how to optimise CCE in schools and universities

To guarantee that students are prepared to handle environmental issues, teachers need to receive better training, and curricula need to be revised to incorporate more sustainability-focused subjects. Offering professional development programs that give educators the tools they need to incorporate sustainability into their lessons is one successful strategy[22]. Even well-meaning educators may find it difficult to communicate the urgency of climate change without the right training. The gap between theory and practice can be closed by integrating multidisciplinary methods and bolstering teacher preparation. Since many educator encounter obstacles because of inadequate professional development and curriculum support, it is imperative to invest in teacher training and curriculum development for effective climate education[23]. Educators may find it difficult to present accurate and interesting climate lessons if they are not properly trained.

To give novice educators the skills and pedagogical techniques they need for CCE, Initial Teacher Education (ITE) has to be significantly improved. Furthermore, for active educators, climate change-focused Continuing Professional Development (CPD) options must be easily available and pertinent. Enhancing teachers' comprehension of climate science and associated ideas, such as climate justice, should be the goal of these CPD programs. They should also offer useful methods for incorporating climate change issues into other subjects and provide workshops regularly to offer educators essential skills required for an effective implementation of CCE such as providing advice on how to approach potentially contentious subjects in a fair and age-appropriate way, boosting educators' self-assurance in supporting student-centred learning and climate change critical thinking. While guaranteeing that all students have fair access to climate education, regulations should encourage experiential learning through fieldwork and sustainable initiatives. To create effective, action-oriented climate policy, governments, educators, and environmental specialists must work together[18].

Innovative teaching methods that adjust to these developments should be a proactive response from universities. To enhance the educational experiences of students, facilitators must be prepared to make these adjustments. Young people are more engaged in the implementation of CCE courses when technology and digital tools are incorporated into educational programs. Gamification has been demonstrated to improve student motivation and learning using entertaining features and incentive systems. Climate Change Escape Rooms, Carbon Footprint Challenges, Virtual Reality (VR) Expeditions, and Climate Change Simulations are a few examples.

Universities should also encourage students to think critically and solve problems by incorporating sustainability into a variety of subject areas. To ensure that climate education results in significant action, students benefit from experiential learning opportunities like fieldwork, community projects, and action-based initiatives. To assist students, internalise the significance of changing beliefs and behaviours towards mitigation and adaptation, educational activities should focus on fostering their will and drive, going beyond the technical complexity of climate change. According to the attitude poll, students expressed worry, but they also believed that taking individual action might not be sufficient, indicating the need to give them a sense of agency.

Therefore, project-based learning and other forms of student involvement in climate action greatly increase students' confidence in tackling climate concerns[24]. Students' feeling of agency is strengthened when they actively engage in real-world sustainability projects, transitioning from passive learners to active problem-solvers. It has been demonstrated that this kind of involved learning experience is very successful in fostering long-lasting behavioural changes and expanding knowledge of climate challenges[25]. We can assist students in converting climate concern into climate action by integrating experiential learning into the classroom, making them feel equipped and ready to change the world. Educational institutions ought to support student-led programs like sustainability initiatives and eco-clubs may promote leadership and a sense of accountability as well. Clean-up initiatives and tree planting are examples of experiential learning that humanises climate action and emphasises the value of hands-on participation.

To have a long-lasting effect, climate education needs to go beyond theory and into practical applications. By implementing renewable energy solutions, such as installing solar panels, which not only lower carbon footprints but also act as teaching tools for students learning about clean energy, schools and universities may play a critical role in setting an example of sustainability[26]. Students can be empowered to contribute to actual policy changes through youth advocacy initiatives that link them with environmental organisations and legislators. These strategies aid in converting climate education into a motivator for

sustained environmental involvement[27]. Many people may feel helpless due to the overwhelming nature of climate change, but education that places an emphasis on action and solutions can give pupils a sense of control again. Whether it is through experiential projects, eco-clubs, or direct interaction with legislators, schools must create an atmosphere that encourages students to take charge and innovate. Involving students in practical sustainability initiatives, such energy saving campaigns and tree planting, not only helps them understand the concrete effects of their activities but also cultivates a sense of responsibility. Students are more likely to form enduring eco-friendly behaviours and have a stronger connection to sustainability when they actively engage in environmental initiatives.

To make learning interesting, incorporate climate education into disciplines like science and geography and use interactive techniques like digital simulations and storytelling[22] are part of the methods. Besides, working with environmental organisations allows for field trips, guest lecturers, and practical projects that bring real-world experiences into the classroom. According to research, the best approaches to incorporate sustainability into education are through experiential learning and multidisciplinary instruction, which give students both theoretical and practical abilities[28]. Using interactive, experiential learning techniques and incorporating climate education into already-existing disciplines can have a big impact. Students start to grasp the broad implications of sustainability and climate action when they discover how geography, science, economics, and even literature are all intertwined with climate challenges.

Climate change is a socio-environmental issue as well as an environmental one[29]. The cultural aspects, ideologies, and societal institutions that affect how people view and react to climate change must be recognised and addressed by effective CCE. Strategies for adaptation must be pertinent to people's lived experiences and appropriate for the situation. Reducing communities' susceptibility to climate change and enhancing their ability to adapt are the ultimate objectives of CCE. This entails imparting information and abilities that are immediately applicable to the particular hazards and effects people encounter, such as water scarcity or animal heat stress. Additionally, CCE ought to promote the adoption of adaptive behaviours and instil new values. This can be made easier by encouraging the growth of support networks among students and by offering useful resources, like logs for keeping track of data.

The curriculum should give more precise instructions on what CCE should involve[12]. Although the existing flexibility is helpful, it must be used in conjunction with clear learning goals and recommended climate change-related content for various subject areas. By showing how climate change topics may be effectively included into already-existing subjects, this integration would also aid in addressing the problem of curriculum overload. The significance of CCE in preparing kids for the future must be acknowledged, even though literacy and numeracy are essential.

Fears of politicisation can be reduced with open dialogue and involvement with parents and the community regarding the value and methodology of CCE. It could also be helpful to emphasise the scientific consensus regarding climate change and to concentrate on responsible behaviour and solutions. Facilitating balanced discussions about the various facets of climate change, including the contributions of diverse sectors, is crucial while being mindful of local contexts, especially regarding the agriculture economy. This can be accomplished in a "broad way" by emphasising innovations and sustainable solutions in these fields.

3.3. Discussion

Most educational institutions have a full curriculum, with a focus on learning outcomes that are always connected to the performance of literacy and numeracy in specific core topics. Due to the lack of clear and exact criteria in CCE and inadequate training support, educators felt discouraged and believed that it would be hard for the front-line educators to change CCE instruction. In all honesty, the current globe's transition to

the artificial intelligence (AI) implementation world has made literacy and information, as well as educational methods and technological advancements, easier to manage. To participate or act impulsively when handling the CCE, either the professors or the students are able to employ the rapid advancement of AI in CCE learning.

Students' exposure to critical environmental knowledge is limited when climate themes are neglected in favour of other academic priorities due to a lack of time and funding. To effectively provide climate-related information and make lessons more engaging and action-driven, educators require greater institutional support[31]. To make climate themes more relevant, integrating climate education necessitates not just adding information but also implementing cutting-edge teaching strategies including project-based learning and cross-disciplinary approaches.

To comprehend the psychological and developmental effects of climate change in the present and the near future, the highlights in CCE mostly target the younger generation. This includes examining how climate change affects their well-being, attitudes, and behaviours. Despite their concerns about climate change, adolescents' private-sphere pro-environmental behaviours are examined in relation to those of adults in order to determine the Concern-Behaviour Gap. It talks about possible reasons for this discrepancy, such as climate denial and low environmental self-efficacy. Teenagers' climate scepticism is linked to their core values[32]. The study found that self-enhancement values predict higher scepticism while self-transcendent values indicate lower scepticism. This pattern is mostly constant across the nations examined. This demonstrates how value systems play a fundamental part in how youth view climate change.

Even though the CCE topic has internal consideration angles, external consideration angles might also affect how well CCE is implemented or promoted. The external consideration angle, which includes localism and cultural influence, is typically outside the control of education units or stakeholders. To avoid the CCE in some places or zones being easy or failing, it is important to consider the sensitivity and understanding of local policy or implementation in CCE situations. The concept to facilitate the implementation of CCE is to have an open dialogue with local officials, custom practitioners, and even parents of the learners. A crucial component of success is respect for each element while presenting the concept of CCE.

4. Implications and future research

4.1. Implications

As the first generation to reach adulthood on a planet threatened by climate change, today's youth are in a unique position. Nonetheless, young people play a vital part in climate advocacy as well[33,34]. Understanding young motives for pro-environmental engagement through identity formation, social justice concerns, and the need for autonomy is crucial, according to CCE research. By matching pro-environmental behaviour with teenagers' primary motives, such as autonomy and peer status, the sustainability motive-alignment hypothesis provides a new framework for maximising Climate Change Education (CCE). This has important ramifications on how communicators and educators craft their approaches to be more successful and interesting for youth.

CCE research informs educational policy and resource allocation to ensure that all youth could develop the knowledge, attitudes, and practices needed to address climate change. The national curriculum for education is being updated to include the CCE. In the Irish context, curriculum reform is required to provide defined learning objectives and make it easier to integrate climate change concepts into other curricula. Students' views on climate change are influenced by socioeconomic, cultural, and regional variables. In light of context-specific information dissemination and communication tactics, educational approaches should be

modified to address regional issues and misconceptions. Good CCE cultivates critical abilities like flexibility and problem-solving. It follows that making the most of educational opportunities can help produce future professionals who will be able to handle the challenges posed by a changing climate and support sustainable development.

The "Climate Change Generation" is being shaped by CCE research because its efficacy directly affects whether students have the information, drive, and abilities needed to make a significant contribution to climate action and policy making. Engaging and motivating techniques like gamification and escape rooms boost students' interest, involvement, and ultimately their understanding of climate change since they prefer dynamic and participatory learning experiences. Additionally, CCE enables students to delve deeper and effectively tackle pertinent CCE problems. However, it is possible to reduce the gap between students' concerns and climate change action. It follows that CCE needs to do more than just increase awareness; it needs to give students a sense of agency and the drive to do something worthwhile. This can be accomplished by showcasing the ways in which each of their fields can help solve the global problem.

Research provides an additional special component for the successful implementation of CCE in schools or educational units, even though cultural values, beliefs, and traditions directly influence every new concept or intervention to be implemented. This implies that interventions need to be flexible and adaptive enough to adjust to these changing cultural contexts rather than relying on a strict notion of tradition. The local aggressively seeks out relevant local expertise and integrates it into the planning and execution processes.

Put CCE in context by valuing and understanding local knowledge, which expands upon the target community's historical, cultural, and traditional methods of understanding and interacting with the environment. Recognising and integrating this experiential knowledge makes the CCE curriculum more relevant, reliable, and ultimately more effective in promoting adaptive actions. For instance, higher education needs to redesign its curriculum in every subject to foster a relationship between people and nature that is founded on mutual nurturing and cohabitation rather than dominance. Both contemporary and conventional philosophy will be more important in creating the necessary moral order and social activity. As "reflexive agents" for social action that practice self-criticism and self-improvement and function well in the real world, higher education is supported. The flexibility of the curriculum is a key enabler for motivated teachers to integrate climate change themes.

The growth of CCE is not just constrained by the educational system; teachers' approaches to CCE are also greatly impacted by external factors including media influence and attitudes held by parents, communities, and society. This suggests that to maximise CCE, these outside factors must be considered. For instance, fostering community and parent knowledge and support for CCE could allay concerns about controversy. Furthermore, acknowledging educators' dependence on media underscores the significance of advancing media literacy and granting access to trustworthy information sources.

4.2. Future research

In particular, the call for additional research to better understand the psychological and mental health effects of climate change on youth of all ages, which includes analysing the effects of exposure to extreme weather events, longer-term climatic impacts such as droughts, and existential stressors such as concern about the future. Future research could look at the specific psychological mechanisms underlying these benefits and how they manifest at different developmental stages.

Future researchers may produce a comprehensive or cohesive knowledge of the problem because of the ESD framework's shortcomings, the cross-curriculum approach's fragmentation, and the subpar CCE practices that result from a lack of common conceptualisation and language. Once the definition of CCE

knowledge is established, the education sector must conduct more research to develop effective learning outcomes, assessment instruments, and teaching materials. When developing a CCE curriculum, it is essential to consider the diverse perspectives of all participants to ensure educational equity.

More research might go deeper into the practices and strategies that best facilitate the inclusion of diverse viewpoints to ensure that CCE activities are representative and responsive to the needs of the entire community. This can mean looking at different participatory strategies and assessing how they impact the usefulness and effectiveness of CCE. Comparing the effectiveness of various pedagogical approaches (such as inquiry-based learning, project-based learning, and discussion-based learning) in promoting different aspects of climate change literacy, such as knowledge acquisition, critical thinking, and pro-environmental behaviours, may encourage future researchers to investigate the study zone. Therefore, the useful information regarding the effectiveness of current teaching methods and the recommendations for developing more student-centred approaches may be beneficial to younger students.

Furthermore, rather than focusing solely on pro-environmental behaviour in the private domain, future research should examine the psychological causes and repercussions of the different ways that young people demonstrate their engagement with climate change. This means examining their involvement in political processes, critiques of existing structures, and activism aimed at altering societal norms, such as climate justice movements. Understanding "dangerous dissent," "disruptive dissent," and "dutiful dissent" and their causes and consequences is crucial. This influenced the development of theory-and evidence-based climate education and communication programs that successfully motivate young people to actively participate in tackling climate change in both public and private domains. The differences in the efficacy of climate education initiatives need to be investigated in future studies. Determining when and for whom these activities are successful will be essential to the development of behaviour change theories and the provision of helpful guidance to policymakers. Examining the significance of individual characteristics, environmental influences, and program design elements could be one way to achieve this.

Future studies could specifically look at the psychological barriers that contribute to the concern-behaviour gap in adolescents' pro-environmental private-sphere actions. This could serve as a roadmap for developing more effective strategies to transform climate concern into sustainable everyday routines. The importance of behavioural changes in reducing emissions and notes varying views on the relative benefits of required and optional tactics. Future studies could focus on developing and evaluating strategies for promoting and incorporating sustainable practices in communities and organisations as part of climate action plans, perhaps with the assistance of information obtained from stakeholder engagement processes.

It is crucial to carefully consider local wisdoms and their special ability to enlighten and enhance CCE because the study and application of CCE faced difficulties from a local perspective both before and after advancement. Being 'local' in multicultural, urbanised places is never easy. Future studies should concentrate on interacting with diverse people and implementing culturally responsive CCE solutions while avoiding possible cultural politics. Future research should concentrate on comparative case studies that look at how different provinces or ethnic groups use cultural perspectives in CCE. This could lead to a more nuanced understanding of the role of culture in environmental management and assist in identifying opportunities and difficulties unique to a given location.

5. Conclusion

In accordance with the Sustainable Development Goals (SDG) that the UN set to address the main challenges that the world faces, especially for the younger generation, the article's goal was to draw attention

to the topic of Climate Change Education (CCE). Education is unquestionably a powerful tool for addressing climate-related issues, and the incorporation of CCE into the current curriculum structure is crucial to reaching this objective. The study's objectives were to investigate the causes of the underutilisation of Climate Change Education (CCE) in educational institutions to identify ways to optimise its implementation. The study poses two research questions:

a) What are the factors that Climate Change Education (CCE) is being underutilised in schools and universities?

b) What are the solutions in optimising the implementation of Climate Change Education (CCE) in schools and universities?

After using the Systematic Literature Review (SLR) technique to determine the elements that contributed to or hindered the adoption of CCE in educational institutions, this study was able to offer several practical implementation techniques. This research was able to explore thinking elements in CCE and construct a comprehensive data bank because of the many viewpoints and recommendations from the many papers and materials. A comprehensive plan that covers resource allocation, positive test scenarios, teacher development, technology use, and various evaluation methods is necessary for the implementation of CCE. These components enhance student learning outcomes and equip students to face the demands of the modern world once the combination process is finished. Furthermore, the influence of increasingly important societal issues like climate change and the need of taking local contexts into account when implementing educational reforms like CCE are highlighted by the need for clear standards, improved training, and the incorporation of AI tools for CCE.

Since this review article uses SLR review throughout the writing process, its primary shortcoming is its reliance on secondary data rather than first-hand data collecting; further data or information may be gathered or investigated soon. Due to the importance and foundation of CCE globally, there is a growing trend of the most recent information or news developments. This is because it is one of the most effective ways to raise awareness of the issues that the climate will face in the future. The transformation will surely continue at this point and pick up speed in the foreseeable future, especially since the SDG 17 Goals are a very certain aim to be achieved in 2030. If each person can think and act more broadly from their perspective and progressively expand the activity to the community in the larger concept, every significant issue is under control. This is true for both the first and last implementations of SDG concepts. In conclusion, there is only one planet in the cosmos that is conducive to humankind, and regardless of one's feelings, every nation and individual must adopt CCE.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgement

The authors would like to thank UNITAR International University Malaysia for its support of this research.

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