

Climate Change Education (CCE) Learning Approach as a Framework For Sustainability Education

Syarifatul Luthfia*  <https://orcid.org/0009-0002-8490-7592>

Al-Irsyad Elementary School, Indonesia

ABSTRACT

Earth society has been facing a very complex problem, namely climate change. Climate change has had a huge impact on life such as water crisis, natural disasters, health problems, food scarcity, and other socio-economic problems. Within the UNESCO framework, climate action is one of the thematic priorities of education for sustainable development. Education is a strategic sector to conduct climate change transformation education so that students grow as individuals who have the knowledge, skills and attitudinal values to respond to climate change. The purpose of this study is to review approaches to implementing climate change education in primary and secondary schools from different countries. This study used a systematic literature review method to collect and analyse data from 28 articles relevant to the topic under study. Results of the study classified various of approaches overview, there are curriculum, professional development, learning model, interdiscipliner, project, and community approach. This research shows that climate change education involves not only students and teachers but also the local community. The implications of the results of this study are useful for the development of climate change education as sustainability education.

This is an open access article under [CC-BY-NC 4.0](https://creativecommons.org/licenses/by-nc/4.0/) license.



ARTICLE INFO

Keywords:

Climate change education; climate change approach; sustainability education; climate change learning model

Article History:

Received: 1 Februari 2025

Revised: 1 March 2025

Accepted: 1 May 2025

Published: 28 June 2025

Citation:

Luthfia, S. L. (2025). Climate Change Education (CCE) Learning Approach as a Framework For Sustainability Education. *Educational Researcher Journal*, 2(2), 39–52.

<https://doi.org/10.71288/educationalresearcherjournal.v2i2.32>

Introduction

The earth envolved an environment of a balanced system but but it worsened by human activities in the recent past for about four centuries. The human growth and development achieved at the cost of climate change is destined to gradually disturb life bearing elements of globe (Rahaman & Rahaman, 2019). Climate change exerts a profound influence on ecosystems. There has been a continuous increase in global temperature over the past 130 years, which has had significant repercussions on a multitude of climate-related variables (Nwankwoala, 2015). The climate crisis is the greatest social challenge of the 21st century. Therefore, the agreements of the 2015 Paris Climate Conference discuss to limit global

warming to 1.6 C. This requires mitigate and adapt actions climate change to reduce greenhouse emissions (Kranz et al., 2022).

Climate change is a threat to current and future generations because it influences animal, crop types and yields, vegetation patterns, and cropping season's length (Ahmed et al., 2022) and the phenomenon of climate change represents a significant threat to the development and health over the last century. Climate change threatens respiratory, cardiovascular and renal which may be triggered by heat waves or air pollution (Maxwell & Blashki, 2016). Therefore, the 26th conference of the Parties meeting in Glasgow, signatory parties to the Paris Agreement submitted their updated Nationally Determined Contributions (NDCs) to reduce greenhouse gas emissions. NDCs would help countries steer toward their carbon reduction commitments by 2030, net-zero emissions by 2050, and goal of limiting global temperature rise to 1.5 Celsius by 2100 (Kwauk & Casey, 2021).

Everyone including children, young adults and adolescents are affected by climate change. They must recognise climate risks and the actions they can take to deal with them. Therefore, education at all school levels is essential to face the challenges of climate change for a better living environment in the future (Kranz et al., 2022). In light of the detrimental impact of certain human activities on the environment, it is imperative that we adopt a more sustainable approach to reduce greenhouse gas emissions. Education plays a pivotal role in this endeavour, particularly through the formal education system and other avenues of public enlightenment (Nwankwoala, 2015), to ensure that future generations are equipped with the knowledge and awareness to make informed decisions. It is therefore considered that education is the most effective method for transforming a people's social, psychological, physical, political, intellectual and developmental characteristics. The curriculum is the means by which this transformation is achieved (Ahmed et al., 2022).

Education has the potential to influence attitudes and shape commitments and actions throughout the lifespan. The successful mitigation and drawdown of global CO₂ levels will require a structural approach, with education representing a crucial element of social infrastructure (Kwauk & Casey, 2021). Climate change would seem to some to be a pressing issue which American schools should take up as a topic of inquiry (Long & Henderson, 2023). The most significant potential contribution of education to effective climate change adaptation is its capacity to facilitate preparation for and learning from climate impacts (Feinstein & Mach, 2020). Teaching climate change is a challenge for teachers. Developing a deep understanding about climate change is challenging for teacher because the underlying scientific principles are complex, and understanding why scientists that Earth's global climate is changing is also complex. To gain better understanding, students need to engage in epistemic cognitive processes that reflect scientific reasoning used to connect evidence and explanations (Lombardi et al., 2016).

The aim of this research is to gain an in-depth insight into the various approaches of Climate change Education (CCE) application. This study employs the Systematic Literature Review (SLR) method to gather, analyze, and synthesize data from various relevant articles spanning from 2015 to 2024. Through the analysis of 28 selected articles, this research identifies significant findings related to the application of CCE approaches. The results of this study provide insights for

local policy makers, schools, and educators in facilitating the implementation of climate change education both in the classroom and outside the classroom. The novelty of this research lies in the comprehensive and systematic SLR approach employed to explore various overview of CCE approaches. There are overview for curriculum, personal development, learning model, interdisciplinary, project, and community approaches. This study is expected to contribute conceptually and practically to advancing practice of CCE both formal or non formal for young generations.

Method

The study utilized the Systematic Literature Review (SLR) method, which entailed the identification, examination, evaluation, and interpretation of all research studies gathered. The data and findings presented in this study are based on a systematic and balanced analysis of relevant sources. The key search term was used, the keyword is climate change education* OR learning* OR teaching* OR curriculum* OR approach* NOT university from 2015 to 2024. A total of 440 studies were screened from google scholar, scopus, and springer through Harzing's Publish or Perish application. There are 28 relevant articles were identified and collected by the researcher. Twenty-eight articles were selected based on their alignment with CCE (Climate Change Education) learning approaches or strategies in schools across the country in the world. The researcher excluded the university level, thus the study is limited to the early childhood, primary and secondary education levels. The PRISMA schema is presented in figure 1.

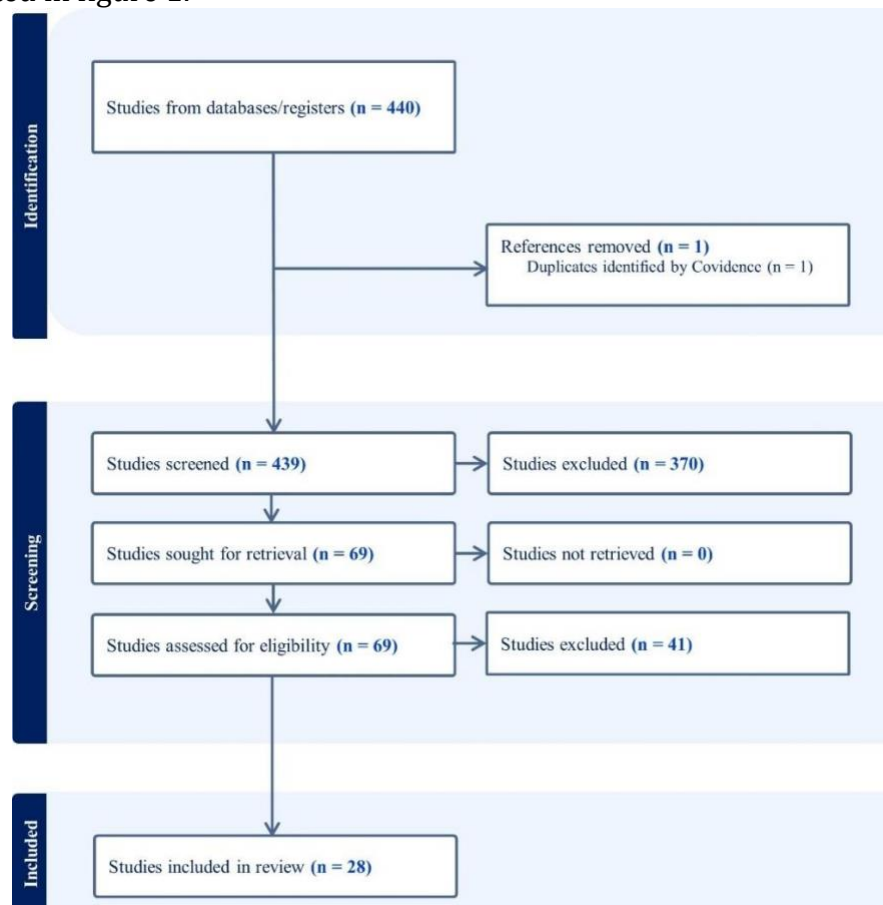


Figure 1. The PRISMA schema by covidence softwere

Results and Discussion

The results of the research conducted by researchers were 28 articles and summarised into a graph in Figure 2 and the researcher will explain for each approach.

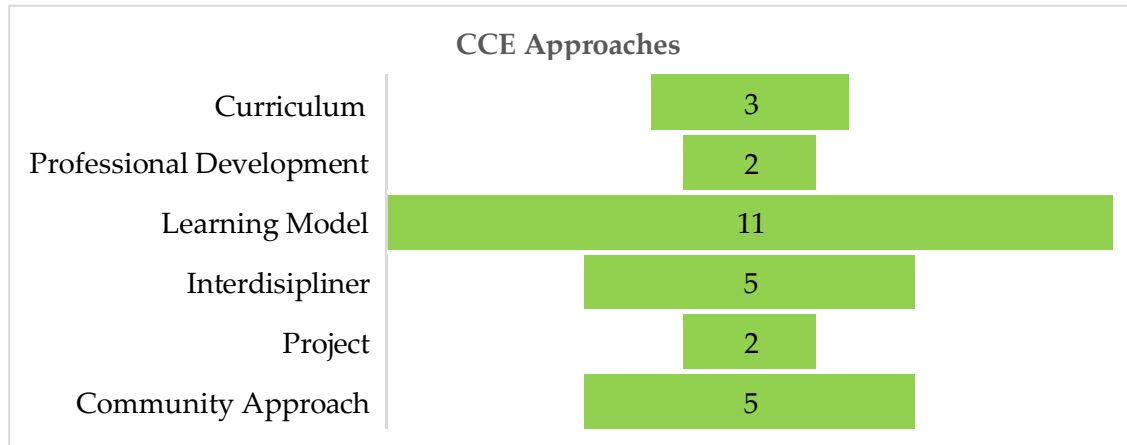


Figure 2. CCE approaches in the world 2015-2024

3.1 Curriculum

The following Table 1 presents the results of an analysis of 3 articles on the CCE curriculum.

Table 1. CCE curriculum

Author	Results
(Cantell et al., 2019)	The research posits that the bicycle curriculum contributes to CCE (Wheels: knowledge and thinking skills; Frame: identity, values, and worldview; Chain and pedals: action; Saddle: motivation and participation; Brakes: operational barriers; Lights: hope and emotion; Handlebar: future orientation)
(Howard-Jones et al., 2021)	The majority of teachers in the UK (51%) favour a cross-curriculum approach involving six or more subjects, which would deliver CCE (interdisciplinary CCE). Teachers favour action-based and social justice CCE (Climate Change Education) curriculum. These include mitigation projects such as conservation, local tree planting and family advocacy. Local campaigns (e.g. legal demonstrations) are considered appropriate in the primary/middle school transition period
(Cheung, 2024)	PISA data shows that 15-year-old students from Denmark, the UK and Finland show low levels of optimism about the future of climate change. This is partly influenced by informal science literacy including multimodal and multimedia texts. Therefore, there is a need to develop a future-orientated climate education optimism curriculum. Optimism is based on an attitude of hope and anticipation.

The first study for the curriculum aspect is presented in the form of a bicycle model. CCE model is imaged as a bicycle that required all of its parts function

together and needed a user to be constant motion. Bicycle model was good presented had highlighted the essential aspects of CCE and putting these parts together to form one entity (knowledge and thinking skills; identity, values, and worldview; action; motivation and participation; operational barriers; hope and emotion; future orientation) (Cantell et al., 2019). In line with this model, (Cheung, 2024) stated that the Optimism Curriculum as a further insight into developing future-oriented CCE. Future-oriented optimism curriculum as encompassing hope and anticipation the climate future. Background Developed this curriculum based on the outcome of 15-year-old students' optimism about climate change future was conducted on the PISA in Denmark, UK and Finland. Based on this finding, students' hope and anticipation about climate change needs to be developed and a future-oriented optimism curriculum is part of the solution.

In addition, CCE's interdisciplinary curriculum was action-based and social justice was another good insight (Howard-Jones et al., 2021). A social justice curriculum was recommended in the 21st century (Moloi et al., 2023). (Howell & Allen, 2019) found that the social justice implications of climate change have been recognised by educators in the UK. Social justice principles had significant benefits such as personal reflection, challenge, and evaluation (Neville, 2014). (C. D. Trott, 2024) outcome study showed that young people recommended an emphasis on equity and action-oriented CCE to equip all learners with the knowledge and skills to make an active contribution to climate change.

3.2 Professional Development

The following Table 2 presents the results of an analysis of 2 articles on the professional development.

Table 2. Professional Development on CCE

Author	Results
(Shea et al., 2016)	The Climate Change Academy is a hybrid professional development programme, combining face-to-face and online learning, designed to equip formal and informal science teachers at the primary and secondary levels with the knowledge and skills to effectively teach climate change. The programme's outcomes demonstrate that it has enhanced climate learning and pedagogical strategies for teaching climate change. Additionally, students had positive impacts on aspects of trust and awareness regarding climate change.
(Madden et al., 2023)	The findings indicated that educators lacked the requisite preparedness to effectively address climate change in the classroom. On a scale of 0-10, the average teacher confidence in their ability to teach climate change was 5.1, while the average interest in learning about effective climate change teaching was 7.8. In light of the aforementioned findings, this research proposes the following recommendations: <ol style="list-style-type: none"> 1. The design of a teacher professional development experience through the NGSS website should engage with crosscutting concepts, science practices, and core areas. 2. The NGSS standards should identify clear examples of climate change. 3. Present clear descriptions of climate change science phenomena and activities

The teaching of climate change requires a high level of preparation on the

part of educators, given the magnitude of the challenge it presents to the planet. A significant number of educators find the subject of climate change challenging to teach due to their limited understanding of the scientific principles involved and the prevalent perception of controversy or threat to personal beliefs, which is often misplaced (Plutzer & Hannah, 2018). Professional development (PD) in the teaching of climate change is an essential element in the acquisition of conceptual knowledge by both teachers and students (Drewes et al., 2018) The results of the study showed that professional development could enhance teachers' knowledge and skills to teach climate change effectively. Teachers can design effective pedagogical strategies for teaching climate change. The government should contribute for CCE and provide programme or website to develop professional development or material content (Madden et al., 2023; Shea et al., 2016).

3.3 Learning Model

The following Table 3 presents the results of an analysis of 11 articles on the learning model.

Table 3. Learning model of CCE

Author	Population	Learning model	Aspects
(Karpudewan et al., 2014)	Primary School	A 5E learning cycle approach (engagement, exploration, explanation, elaboration, and evaluation)	Knowledge and attitude
(Dawson, 2015)	Secondary School	A inquiry-based module (included activities used analogy, prediction-observation-explanation, direct investigation, and argumentation)	Knowledge (interconnection concepts)
(Douglas & Brauer, 2021; Fung et al., 2015; Wu & Lee, 2015)	General	Gamification	Attitudes
(Jacobson et al., 2017)	Secondary School	PF (Productive Failure)	Student's interest on Climate change topic
(Markowitz et al., 2018)	Secondary School	Immersive Virtual Reality (IVR)	Knowledge and attitude
(Anggraeni & Aminatun, 2019)	Secondary School	Android-based modules with the Search, Solve, Create, and Share (SSCS)	Critical thinking-skills
(Dormody et al., 2021)	Secondary School	The integration of inquiry-based learning and experiential education	Knowledge

Author	Population	Learning model	Aspects
(Mufida et al., 2022)	Secondary School	Immersive Virtual Learning (IVL)	Knowledge and thinking skills
(Efwindi et al., 2023)	Secondary School	The integration of the PBL (Problem-Based Learning Model) and digital poster within the TPACK (Technological, Pedagogical, and Content Knowledge)	Critical thinking-skills

A review of 11 journals has revealed a variety of findings related to the CCE learning approach. A review of the literature suggests that educators can improve the different aspects and there are knowledge, attitudes, interest in the CCE topic, thinking skills especially critical thinking. This learning models supports the objectiv of CCE. The objective of environmental education is not merely to enhance the knowledge base of individuals, but also to facilitate the development of sustainable societies by fostering changes in environmental attitudes and behaviours, and to safeguard the sustainable environment (Guerra et al., n.d.). The results of the study provide insight for teachers to apply various learning models which are summarised in TABLE 3.

3.4 Interdisciplinary

The following Table 4 presents the results of an analysis of 5 articles on the interdisciplinary.

Table 4. Interdisciplinary of CCE

Author	Result
(Zangori et al., 2017)	The socio-scientific issue (SSI) model offers a constructive approach for secondary students to develop robust conceptual frameworks concerning the interconnections between the carbon cycle and climate change.
(C. Trott, 2019)	The SCA (Science, Camera, Action) programme is an climate change learning based on participatory art. It was conducted after school for 15 weeks. The programme employed the photovoice method, which is a form of action research. This involved the use of digital photography to identify problems, facilitate team and social discussion, and encourage change in action.
(Bentz, 2020)	The utilisation of art as a pedagogical tool has the potential to facilitate transformative and profound learning in the context of climate change education.
(Putri et al., 2023)	The findings of the study indicated that students' capacity to make informed decisions regarding climate change remains limited, with their decisions largely influenced by their personal perspectives. In light of these findings, it is imperative to develop socio-scientific materials based on Android for the context of climate change, with the aim of fostering the decision-making abilities of students.

Author	Result
(Álvarez et al., 2024)	Students' understanding of climate change phenomena and actions can be enhanced through arts and science-based learning approaches. Through an arts and science integration workshop from March to May 2024, students were invited to imagine climate change and create artistic worlds through interactive photos and virtual maps. This process involves both scientific and artistic processes.

The finding of the study indicated that integrating interdisciplinary or intradisciplinary approaches from diverse sources of knowledge, such as social and natural sciences, is a complex yet crucial endeavour in climate change research and the development of climate change action strategies (Kieslinger et al., 2019). A number of interdisciplinary journals have demonstrated that CCE can be integrated with the arts or humanities (Álvarez et al., 2024; Bentz, 2020; C. Trott, 2019). (Álvarez et al., 2024) posited that strong synergy of scientific and artistic perspectives on climate change can evoke a sense of moral responsibility in students, motivating them to engage in proactive action through surprising and fun way experience and emotions in learning process. The CCE topic for young people is perceived as being of an abstract, distinct, and complex nature, and contributes to the development of feelings of sadness, hopelessness, and anxiety. Those engaged in the teaching and facilitation of young people, as well as those engaged in research, can utilise the potential of the arts (Bentz, 2020).

A socio-scientific approach could be employed in the context of climate change education (Putri et al., 2023; Zangori et al., 2017). Socio-scientific issue can create ideal context for bridging science and lived experience of students (Sadler, 2011). Socio-scientific Issue (SSI) is a new trend in science education to promote the science literacy. Science literacy promotes a potential learning alternative that involves the aspects of science and society. The resolution of SSI cannot be achieved through the exclusive application of scientific knowledge. Rather, it necessitates the integration of diverse social elements and viewpoints (Genisa et al., 2020). The phenomenon of climate change is a complex context, comprising both scientific knowledge and social aspects. The SSI can be an effective approach to teaching about it.

3.5 Project

The following Table 5 presents the results of an analysis of 2 articles on the project of CCE.

Table 5. Project of CCE

Author	Results
(Cutter-Mackenzie & Rousell, 2019)	The Climate Change + Me project, which is government-funded and supported, provides children and young people with the opportunity to adopt a proactive stance on climate change and environmental issues.
(Rudd et al., 2020)	The "You and CO2" programme is a STEAM initiative that aims to foster self-reflection among students on environmental issues and encourage them to engage in positive social action. Upon completion of the programme, students are tasked with producing digital fiction, thereby affording them the opportunity to engage in creative exploration.

CCE can teach through project based learning (Rudd et al., 2020)(Sadler, 2011). The promotion and application of project-based learning could be beneficial and meaningful for the development of CCE (Yerevan, 2022). Project-based learning involves students working on vital and engaging real-world challenges over an extended period of time. The study's findings indicate that CCE can be effectively implemented through projects, motivating students and social to adopt proactive and socially engaged approaches to addressing climate change (Cutter-Mackenzie & Rousell, 2019; Rudd et al., 2020).

3.6 Community Approach

The following Table 6 presents the results of an analysis of 5 articles on the community approaches of CCE.

Table 6. Community approach of CCE

Author	Result
(Stevenson et al., 2017)	The co-curricular initiative and community approach represents a potential solution to the issue of time constraints within the curriculum and the integration of climate change learning in the classroom.
(Ha'apio et al., 2017)	The socio-ecological approach can facilitate the transformation of communities of all ages in rural areas through active engagement with the challenges posed by climate change.
(Luey et al., 2023)	The indigenous communities of Ha'pai and Port Villa are committed to upholding their cultural and ancestral values. In light of this, educational institutions have the potential to develop an inclusive curriculum that incorporates local cultural values in order to address the challenges posed by climate change and natural disasters.
(Stapleton, 2019)	This study promotes climate change education as applied contextual learning (from abstract to real phenomena) and calls it a social justice approach. Students carry out this programme by visiting slum settlements in Dhaka, Bangladesh. Students directly learned, interviewed, surveyed and directly felt the impact of climate change.
(Siegener & Stapert, 2020)	Humanities-based CCE can increase students' literacy and enthusiasm for climate change. In addition, the focus on action or solutions can be strengthened by incorporating authentic and meaningful action projects in local communities. Examples such as field trips, reforestation projects, developing school-community collaborations enhance project-based learning that has meaningful impact.

A review of several academic journals has revealed a variety of insights related to the CCE through a community approach. The studies conducted by (Ha'apio et al., 2017) and (Luey et al., 2023) indicated that the CCE could be effectively taught through an indigenous community-based approach. Indigenous which also known as traditional or local knowledge refers to place-based knowledge rooted in the culture and traditions of a particular community. The study by (Granderson, 2017) demonstrated that indigenous knowledge constituted a significant repository of information and practices for enhancing adaptive capacity in the Pacific region in the context of climate change. Furthermore, it could also foster conservative attitudes within the community. The findings of study showed that connection between indigenous communities and ancestral territories, emphasised the significance of upholding indigenous

sovereignty over land for sustainable adaptation to climate change. Relational learning is important as a form education, fostering resilience rooted in preserving traditional practices and spaces (Datta, 2024). Based on that, it given insight for us that utilising indigenous community for CCE is one good suggestion to consider.

Conclusion

CCE (Climate Change Education) constitutes a component of the field of sustainability education. It is crucial to engage in discourse on this subject. There are a number of approaches that have the potential to enhance the efficacy of CCE. These include:

1. Curriculum. The implementation of curricula such as the bicycle curriculum, the optimism curriculum, the action-based curriculum and the social justice curriculum give good insight to apply
2. The development of the individual. Personal development is a crucial aspect that enables educators to teach effectively.
3. Learning models. There are numerous learning models that educators may utilise within the classroom setting. These include the 5E cycle, inquiry-based modules, gamification, PF (productive failure), IVR (immersive virtual reality), android-based SSCS modules, inquiry and experiential learning, and the integration of PBL and TPACK (technological, pedagogical, and content knowledge). The application of these models has the potential to enhance students' knowledge, thinking skills, and attitude of students.
4. Interdisciplinary. The CCE approach is interdisciplinary, allowing for integration with SSI (socio-scientific issues), as well as the arts and humanities.
5. Project. CCE project encourages motivating students and social to adopt proactive and socially engaged approaches to addressing climate change
6. Community approach. A community-based approach, particularly one that is indigenous and community-oriented, can be employed in the context of CCE learning.

References

- Ahmed, A. H., Ibrahim, O. A., & Agunbiade, M. W. (2022). Integrating Climate Change and Smart Agriculture Contents into Nigerian School Curriculum. *Indonesian Journal of Curriculum and Educational Technology Studies*, 10(1), 1–8. <https://doi.org/10.15294/ijcets.v10i1.50938>
- Álvarez, M. Á., López, I. O., Fonseca, M. B. R. de, & ... (2024). An educational project exploring the synergy between art and science to improve understanding and awareness of climate change. ... , 2024: *Climate Change ...*, Query date: 2024-06-30 19:36:31. <https://dialnet.unirioja.es/servlet/articulo?codigo=9555296>
- Anggraeni, T., & Aminatun, T. (2019). Understanding Climate Change Topics Critically Through Android-based Module for Student. *Indonesian Journal of Curriculum and Educational Technology Studies*, 7, 80–88. <https://doi.org/10.15294/ijcets.v7i2.32146>
- Bentz, J. (2020). Learning about climate change in, with and through art. *Climatic Change*, 162(3), 1595–1612. <https://doi.org/10.1007/s10584-020-02804-4>

- Cantell, H., Tolppanen, S., Aarnio-Linnanvuori, E., & Lehtonen, A. (2019). Bicycle model on climate change education: presenting and evaluating a model. *Environmental Education Research*, 25, 1–15. <https://doi.org/10.1080/13504622.2019.1570487>
- Cheung, K. K. C. (2024). A Structural Model of Future-Oriented Climate Change Optimism in Science Education: PISA Evidence from Countries with Top Environmental Protection Index. *Research in Science Education*, 1–21. <https://doi.org/10.1007/s11165-024-10164-7>
- Cutter-Mackenzie, A., & Rousell, D. (2019). Education for what? Shaping the field of climate change education with children and young people as co-researchers. *Children's Geographies*, 17(1), 90–104. <https://doi.org/10.1080/14733285.2018.1467556>
- Datta, R. (2024). Relationality in Indigenous Climate Change Education Research: A Learning Journey from Indigenous Communities in Bangladesh. *Australian Journal of Environmental Education*. <https://doi.org/10.1017/aee.2024.13>
- Dawson, V. (2015). Western Australian High School Students' Understandings about the Socioscientific Issue of Climate Change. *International Journal of Science Education*, 37(7), 1024–1043. <https://doi.org/10.1080/09500693.2015.1015181>
- Dormody, T., Skelton, P., Rodriguez, G., DuBois, D., & Vanleeuwen, D. (2021). Assessing the Impact of Weather and Climate Curriculum on Youth Science Comprehension. *Journal of Agricultural Education*, 62, 2021. <https://doi.org/10.5032/jae.2021.03153>
- Douglas, B. D., & Brauer, M. (2021). Gamification to prevent climate change: A review of games and apps for sustainability. *Current Opinion in Psychology*, Query date: 2024-06-30 19:36:31143 cites: <https://scholar.google.com/scholar?cites=9232631092649113701> & <https://www.sciencedirect.com/science/article/pii/S2352250X21000555> <https://benjaminddouglas.com/s/Gamification-and-Sustainability-Print.pdf>
- Drewes, A., Henderson, J., & Mouza, C. (2018). Professional development design considerations in climate change education: teacher enactment and student learning. *International Journal of Science Education*, 40(1), 67–89. <https://doi.org/10.1080/09500693.2017.1397798>
- Efwinda, S., Puspita, I., Damayanti, P., Hakim, A., & ... (2023). ENHANCING CRITICAL THINKING ON CLIMATE CHANGE: TPACK IMPLEMENTATION IN PBL WITH DIGITAL POSTERS. *EDUSAINS*, Query date: 2024-06-30 19:36:31. <https://journal.uinjkt.ac.id/index.php/edusains/article/view/33230>
- Feinstein, N. W., & Mach, K. J. (2020). Three roles for education in climate change adaptation. *Climate Policy*, 20(3), 317–322. <https://doi.org/10.1080/14693062.2019.1701975>
- Fung, M. K., Tedesco, L. R., & Katz, M. E. (2015). Games and climate literacy. *Nature Geoscience*, Query date: 2024-06-30 19:36:314 cites: <https://scholar.google.com/scholar?cites=5058407888593294374> & <https://www.nature.com/articles/ngeo2499> <https://www.nature.com/articles/ngeo2499>
- Genisa, M. U., Subali, B., Djukri, Agussalim, A., & Habibi, H. (2020). Socio-scientific issues implementation as science learning material. *International Journal of Evaluation and Research in Education*, 9(2), 311–317. <https://doi.org/10.11591/ijere.v9i2.20530>
- Granderson, A. A. (2017). The role of traditional knowledge in building adaptive capacity for climate change: Perspectives from Vanuatu. *Weather, Climate, and Society*, 9(3), 545–561. <https://doi.org/10.1175/WCAS-D-16-0094.1>
- Guerra, A. O., Pereira De Carvalho, J., Schoefs, F., & Chevreuril, M. (n.d.). *Preparing engineering students for collaborative project-work Piloting an online course on PBL and project management.*

- Ha'apio, M. O., Gonzalez, R. E., Wairiu, M., Morrison, K. D., & ... (2017). *Assessing the potential role of education as a tool for adaptation to climate change in two rural communities in Solomon Islands* (Issue Query date: 2024-06-30 19:36:311 cites: [https://scholar.google.com/scholar?cites=16554377126066191745 & as_sdt=2005 & scioldt=2007 & hl=en](https://scholar.google.com/scholar?cites=16554377126066191745&as_sdt=2005&scioldt=2007&hl=en)). climate.educationevidence.io. <https://climate.educationevidence.io/lib/ZS7WTK6N>
- Howard-Jones, P., Sands, D., Dillon, J., & Fenton-Jones, F. (2021). The views of teachers in England on an action-oriented climate change curriculum. *Environmental Education Research*, 27(11), 1660–1680. <https://doi.org/10.1080/13504622.2021.1937576>
- Howell, R. A., & Allen, S. (2019). Significant life experiences, motivations and values of climate change educators. *Environmental Education Research*, 25(6), 813–831. <https://doi.org/10.1080/13504622.2016.1158242>
- Jacobson, M. J., Markauskaite, L., Portolese, A., Kapur, M., Lai, P. K., & Roberts, G. (2017). Designs for learning about climate change as a complex system. *Learning and Instruction*, 52, 1–14. <https://doi.org/https://doi.org/10.1016/j.learninstruc.2017.03.007>
- Karpudewan, M., Roth, W., & Abdullah, M. N. S. (2014). Enhancing Primary School Students' Knowledge about Global Warming and Environmental Attitude Using Climate Change Activities. *International Journal of Science Education*, 37. <https://doi.org/10.1080/09500693.2014.958600>
- Kieslinger, J., Pohle, P., Buitrón, V., & Peters, T. (2019). Encounters between experiences and measurements: The role of local knowledge in climate change research. *Mountain Research and Development*, 39(2), R55–R68. <https://doi.org/10.1659/MRD-JOURNAL-D-18-00063.1>
- Kranz, J., Schwichow, M., Breitenmoser, P., & Niebert, K. (2022). The (Un)political Perspective on Climate Change in Education—A Systematic Review. In *Sustainability (Switzerland)* (Vol. 14, Issue 7). MDPI. <https://doi.org/10.3390/su14074194>
- Kwauk, C., & Casey, O. (2021). *Approaches to quality education for climate action A new green learning agenda Approaches to quality education for climate action*.
- Lombardi, D., Nussbaum, E. M., & Sinatra, G. M. (2016). Plausibility Judgments in Conceptual Change and Epistemic Cognition. *Educational Psychologist*, 51(1), 35–56. <https://doi.org/10.1080/00461520.2015.1113134>
- Long, D., & Henderson, J. (2023). Climate change as superordinate curriculum? *Research in Education*, 117(1), 73–87. <https://doi.org/10.1177/00345237231160080>
- Luey, E. P., Manning, R., & Ratuva, S. (2023). *The status of Indigenous knowledge, environmental issues and climate change in science education: Talanoa from Ha 'apai (Tonga) and Port Vila (Vanuatu) ...* (Issue Query date: 2024-06-30 19:36:31). ir.canterbury.ac.nz. <https://ir.canterbury.ac.nz/items/8a961fe4-e68e-4cb2-b4fb-3ff2f3a01fce>
- Madden, L., Ammentorp, L., Magee, N., & Taylor, G. (2023). *Marine Science, Climate Change, and the Next Generation Science Standards: Understanding the Knowledge and Perspectives of K-8 New Jersey Teachers* (Issue Query date: 2024-06-30 19:36:31). repository.library.noaa.gov. https://repository.library.noaa.gov/view/noaa/60986https://repository.library.noaa.gov/view/noaa/60986/noaa_60986_DS1.pdf
- Markowitz, D. M., Laha, R., Perone, B. P., Pea, R. D., & Bailenson, J. N. (2018). Immersive Virtual Reality Field Trips Facilitate Learning About Climate Change. *Frontiers in Psychology*, 9. <https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2018.02364>
- Maxwell, J., & Blashki, G. (2016). Teaching about climate change in medical education: an opportunity. In *Journal of Public Health Research* (Vol. 5).

- Moloi, T. J., Matabane, M. E., Simuja, C., Seo, B.-I., & Tarman, B. (2023). Constructing a Social Justice Curriculum Policy in the 21st Century. *Research in Educational Policy and Management*. <https://api.semanticscholar.org/CorpusID:266705393>
- Mufida, A. Al, Widodo, A., & Solihat, R. (2022). Application of Immersive Virtual Learning to Understanding Climate Change Concepts and Thinking Process Skills. *Jurnal Penelitian Pendidikan ...*, Query date: 2024-06-30 19:36:311 cites: <https://scholar.google.com/scholar?cites=1826792652185845226> & as_sdt=2005 & scioldt=2007 & hl=en. <https://jppipa.unram.ac.id/index.php/jppipa/article/view/1673><https://jppipa.unram.ac.id/index.php/jppipa/article/download/1673/1361>
- Neville, H. A. (2014). Social Justice Mentoring: Supporting the Development of Future Leaders for Struggle, Resistance, and Transformation. *The Counseling Psychologist*, 43(1), 157–169. <https://doi.org/10.1177/0011000014564252>
- Nwankwoala. (2015). *Causes of Climate and Environmental Changes: The need for Environmental-Friendly Education Policy in Nigeria*. 224–234. <http://www.metoffice.gov.uk>
- Plutzer, E., & Hannah, A. L. (2018). Teaching climate change in middle schools and high schools: investigating STEM education’s deficit model. *Climatic Change*, 149(3), 305–317. <https://doi.org/10.1007/s10584-018-2253-8>
- Putri, S. I., Hamidah, I., & Liliawati, W. (2023). Analysis of Needs for Development of Android-Based Socioscientific Issues Teaching Materials on the Topic of Climate Change to Improve Students’ Decision-Making *Jurnal Penelitian Pendidikan ...*, Query date: 2024-06-30 19:36:311 cites: <https://scholar.google.com/scholar?cites=7540198692675880464> & as_sdt=2005 & scioldt=2007 & hl=en. <https://jppipa.unram.ac.id/index.php/jppipa/article/view/3694><https://jppipa.unram.ac.id/index.php/jppipa/article/download/3694/3650>
- Rahaman, S., & Rahaman, H. (2019). Designing Academic Curriculum on Climate Change: A Proposal. In *International Journal of Research in Engineering, IT and Social Sciences* (Vol. 565, Issue 5). <http://indusedu.org>
- Rudd, J. A., Horry, R., & Skains, R. L. (2020). You and CO2: a Public Engagement Study to Engage Secondary School Students with the Issue of Climate Change. *Journal of Science Education and Technology*, 29(2), 230–241. <https://doi.org/10.1007/s10956-019-09808-5>
- Sadler, T. (2011). *Socio-scientific Issues in the Classroom: Teaching, Learning and Research* (Vol. 39). <https://doi.org/10.1007/978-94-007-1159-4>
- Shea, N., Mouza, C., & Drewes, A. (2016). Climate Change Professional Development: Design, Implementation, and Initial Outcomes on Teacher Learning, Practice, and Student Beliefs. *Journal of Science Teacher Education*, 27, 235–258. <https://doi.org/10.1007/s10972-016-9456-5>
- Siegner, A., & Stapert, N. (2020). Climate change education in the humanities classroom: a case study of the Lowell school curriculum pilot. *Environmental Education Research*, 26(4), 511–531. <https://doi.org/10.1080/13504622.2019.1607258>
- Stapleton, S. R. (2019). A case for climate justice education: American youth connecting to intragenerational climate injustice in Bangladesh. *Environmental Education Research*, 25(5), 732–750. <https://doi.org/10.1080/13504622.2018.1472220>
- Stevenson, R., Nicholls, J., & Whitehouse, H. (2017). What Is Climate Change Education? *Curriculum Perspectives*, 37. <https://doi.org/10.1007/s41297-017-0015-9>
- Trott, C. (2019). Reshaping our world: Collaborating with children for community-based climate change action. *Action Research*, 17, 42–62. <https://doi.org/10.1177/1476750319829209>
- Trott, C. D. (2024). Envisioning action-oriented and justice-driven climate change education: Insights from youth climate justice activists. *Children & Society*. <https://api.semanticscholar.org/CorpusID:267948349>

- Wu, J., & Lee, J. (2015). Climate change games as tools for teaching and engagement. *Nature Climate Change*, 5.
- Yerevan. (2022). *TEACHING CLIMATE CHANGE USING PROJECT-BASED LEARNING A manual for teachers*.
- Zangori, L., Peel, A., Kinslow, A., Friedrichsen, P., & Sadler, T. D. (2017). Student development of model-based reasoning about carbon cycling and climate change in a socio-scientific issues unit. *Journal of Research in Science Teaching*, 54(10), 1249–1273. <https://doi.org/https://doi.org/10.1002/tea.21404>