Nusantara 1

Artikel Galleys Scientica-Vol2.4-1971.pdf

Check - No Repository 2

New Test

Konsorsium PTS Batch 2

Document Details

Submission ID

trn:oid:::1:3348759196

Submission Date

Sep 23, 2025, 3:04 PM GMT+7

Download Date

Sep 23, 2025, 3:05 PM GMT+7

File Name

Artikel_Galleys_Scientica-Vol2.4-1971.pdf

File Size

530.4 KB

9 Pages

4,097 Words

25,202 Characters

13% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

▸ Bibliography

Match Groups

28 Not Cited or Quoted 8%
Matches with neither in-text citation nor quotation marks

19 Missing Quotations 6%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

8% 🌐 Internet sources

8% 📖 Publications

2% 👤 Submitted works (Student Papers)

Match Groups

- **28** Not Cited or Quoted 8%
  Matches with neither in-text citation nor quotation marks

- **19** Missing Quotations 6%
  Matches that are still very similar to source material

- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation

- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

8%	🌐 Internet sources
8%	📖 Publications
2%	👤 Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

| 1 | Publication | | |
| "Climate Change and the Role of Education", Springer Science and Business Medi... | | | **<1%** |

| 2 | Publication | | |
| Irfan Nursalima, Rita Fitriani, Dea Diella. "Enhancing Students' Biodiversity Litera... | | | **<1%** |

| 3 | Internet | | |
| kau.diva-portal.org | | | **<1%** |

| 4 | Internet | | |
| www.jet.or.id | | | **<1%** |

| 5 | Internet | | |
| archive.interconf.center | | | **<1%** |

| 6 | Internet | | |
| nawalaeducation.com | | | **<1%** |

| 7 | Internet | | |
| www.helsinki.fi | | | **<1%** |

| 8 | Publication | | |
| Maila D.H. Rahiem. "Towards Resilient Societies: The Synergy of Religion, Educati... | | | **<1%** |

| 9 | Student papers | | |
| University of Western Sydney | | | **<1%** |

| 10 | Internet | | |
| ojs.staialfurqan.ac.id | | | **<1%** |

11   Internet

jurnal.feb-umi.id   <1%

12   Student papers

Sheffield Hallam University   <1%

13   Publication

Rana A. Hijazi, Amer A. Hijazi, Verity Jones. "Climate literacy for students in highe...   <1%

14   Internet

edu.pubmedia.id   <1%

15   Internet

e-journal.undikma.ac.id   <1%

16   Internet

mpra.ub.uni-muenchen.de   <1%

17   Internet

otter-project.eu   <1%

18   Internet

ufdc.ufl.edu   <1%

19   Internet

ummaspul.e-journal.id   <1%

20   Publication

"Advances in Applications of Rasch Measurement in Science Education", Springer ...   <1%

21   Publication

Amy Strachan, Andy Markwick. "Using a scoping review to inform a planetary-con...   <1%

22   Publication

Juliana da Silva Aureliano. "Oficina de projetos: promotora de desempenho escol...   <1%

23   Publication

Michelle Seifert, Moritz Reckling, Jolanda Hermanns. "Linking the Topics "Climate ...   <1%

24   Publication

Shuqi Jia, Shanzhang Ren. "The Significance of Science Content Knowledge for So...   <1%

25 · Publication

Sukardi Abbas, Abusahman Nasim, Julkarnain Syawal, Indriani Fahri. "Designing ...   <1%

26 · Internet

dspace.zcu.cz   <1%

27 · Internet

edepot.wur.nl   <1%

28 · Internet

etd.lib.metu.edu.tr   <1%

29 · Internet

files.eric.ed.gov   <1%

30 · Internet

jep.ppj.unp.ac.id   <1%

31 · Internet

link.springer.com   <1%

32 · Internet

systems.enpress-publisher.com   <1%

33 · Internet

uav.ro   <1%

34 · Publication

Aan Komariah, Taufani C. Kurniatun, Dedy A. Kurniady, Rita Anggorowati, Ade Ga...   <1%

35 · Publication

Michael Kilmister, Annika Herb, Clare Lloyd. "Moving Your University Course Onli...   <1%

36 · Publication

Kimberly Carroll Steward, David Gosselin, Devarati Bhattacharya, Mark Chandler,...   <1%

37 · Publication

Panagiota Asimakopoulou, Panagiotis Nastos, Emmanuel Vassilakis, Assimina An...   <1%

Integration of Climate Education in Science Learning to Foster Students' Environmental Awareness

Ratna Puspitasari
UIN Cyber Syekh Nurjati Cirebon
Email: ratnapuspitasari@syekhnurjati.ac.id

ABSTRAK

Penelitian ini mengkaji integrasi pendidikan iklim dalam pembelajaran IPA untuk menumbuhkan kesadaran lingkungan siswa melalui tinjauan literatur sistematis terhadap 27 artikel ilmiah yang dipublikasikan antara tahun 2020–2025. Tujuan penelitian ini adalah untuk mengidentifikasi pendekatan, strategi, dan model pembelajaran IPA yang efektif dalam mengintegrasikan pendidikan iklim serta mengevaluasi dampaknya terhadap kesadaran lingkungan siswa. Metode penelitian menggunakan tinjauan literatur sistematis dengan kriteria inklusi berupa artikel yang membahas integrasi pendidikan iklim dalam pembelajaran IPA, dipublikasikan pada periode 2020–2025, dan menggunakan pendekatan empiris. Hasil penelitian menunjukkan bahwa pendekatan pembelajaran berbasis inkuiri, pembelajaran berbasis proyek, serta integrasi teknologi seperti Augmented Reality dan media interaktif terbukti efektif dalam meningkatkan pemahaman dan kesadaran siswa tentang iklim. Kolaborasi sekolah–universitas melalui citizen science juga memberikan dampak positif bagi pembelajaran praktis mengenai isu iklim. Pembelajaran yang mengintegrasikan aspek sains, teknologi, sosial, dan humaniora (STEM dan E-STEM) menunjukkan hasil optimal dalam membangun kesadaran kritis siswa. Integrasi pendidikan iklim dalam pembelajaran IPA tidak hanya meningkatkan pengetahuan kognitif, tetapi juga mengembangkan aspek afektif dan keterampilan tindakan siswa terhadap perubahan iklim.
Kata Kunci: pendidikan iklim, pembelajaran ipa, kesadaran lingkungan, tinjauan literatur sistematis, perubahan iklim.

ABSTRACT

This study examines the integration of climate education in science learning to foster students' environmental awareness through systematic literature review of 27 scientific articles published between 2020-2025, the purpose of the research is to identify effective approaches, strategies, and science learning models in integrating climate education and evaluate its impact on students' environmental awareness, the research method uses systematic literature review with Inclusion Criteria An article that discusses the integration of climate education in science learning, published in the period 2020-2025, and using an empirical approach, the results of the study show that the inquiry-based learning approach, project-based learning, and the integration of technologies such as Augmented Reality and interactive media have proven to be effective in increasing students' understanding and awareness of climate, school-university collaboration through citizen science also has a positive impact For practical learning about climate issues, learning that integrates science, technology, social, and humanities (STEM and E-STEM) aspects shows optimal results in building students' critical awareness, the integration of climate education in science learning not only improves cognitive knowledge, but also develops students' affective aspects and action skills against climate change.
Keywords: *climate education, science learning, environmental awareness, systematic literature review, climate change.*

10

INTRODUCTION

Awareness of global climate change continues to increase as a central issue of the 21st century that has a major impact on human life, various studies show that global warming has caused environmental damage and threatens the balance of the world's ecosystem, in the context of education, schools play an important role in shaping students' environmental awareness through the integration of climate education into the learning curriculum, especially Natural Sciences (IPA) as an eye lessons directly related to natural phenomena (Akaygun & Adadan, 2020; Kumar et al., 2023).

Science learning in schools has not fully provided a deep understanding of climate change issues and their impact on life (Illahaqi et al., 2021). The disconnect between science learning and the context of climate change is one of the obstacles in shaping students' critical awareness of the environment (Kim, 2024). Based on the study of Aulia et al. (2024), the use of interactive media and project-based approaches shows more effective results in increasing students' understanding and empathy for climate issues, therefore, the integration of climate education in science learning is a strategic step to bridge this gap.

Previous research has highlighted the importance of a transdisciplinary approach in climate education, but real implementation at the primary and secondary school levels is still limited (Kundariati et al., 2025; Asimakopoulou et al., 2021). One of the main challenges is how to align the science curriculum with actual climate issues without disrupting established learning outcomes, in this context, learning that combines science, technology, and social approaches through inquiry-based and project-based methods becomes a promising alternative (Brumann et al., 2022; Maspul, 2024).

The purpose of this study is to systematically examine various approaches, strategies, and models of science learning that have successfully integrated climate education, as well as evaluate their impact on improving students' environmental awareness, the focus of the research is directed to search for evidence-based findings from the academic literature in the period 2020 to 2025.

This research is different from the study of Aulia et al. (2024) which only focuses on the use of the Climate Kids platform for understanding global warming, and different from Artika and Rosemary (2023) which discusses climate awareness in the local context of Aceh through an E-STEM approach, this study integrates various approaches and outcomes in a broader and comprehensive framework.

The results of the study by Batchelder et al. (2023) show that collaboration between schools and universities in citizen science projects can improve climate understanding in practical terms. While research by Bhattacharya et al. (2021) compares model-based and non-model-based learning approaches to understanding climate systems. Both studies underscore the importance of a variety of learning methods to strengthen students' climate awareness.

Technology-based approaches such as Augmented Reality and interactive media have also been shown to have a positive impact on students' understanding of climate topics (Chen et al., 2024; Kim et al., 2025). The integration of technology in science learning allows the visualization of abstract concepts to become more concrete, increasing student interest and engagement.

Research by Gal (2024) and Clark (2024) emphasizes the importance of building critical awareness of climate issues, which not only rely on cognitive knowledge, but also affective and social aspects, in this context, integrated climate education in science not only aims to increase knowledge, but also foster an attitude of care and responsibility towards the environment.

The integration of climate education in science learning is a relevant and urgent approach to be implemented, this research makes an important contribution in identifying effective strategies, as well as providing a roadmap for the development of contextual and environmentally oriented science learning.

METHDOLOGY

This study uses the Systematic Literature Review (SLR) method to analyze and synthesize findings from various published studies on the integration of climate education in science learning, the SLR method was chosen for its ability to provide a comprehensive and objective analysis of the empirical evidence available in the scientific literature.

The inclusion criteria in this study include: (1) articles that discuss the integration of climate education in science/science learning (2) research published in the 2020-2025 time frame (3) studies that use an empirical approach with a clear methodology (4) articles published in reputable and accessible journals (5) research that focuses on students at primary to secondary education levels.

Exclusion criteria include: (1) articles that only discuss theoretical aspects without empirical evidence (2) studies that do not specifically address the integration of climate education in learning; (3) articles that do not have a clear research methodology (4) publications that are not relevant to the context of formal education.

The literature search process was carried out systematically by identifying relevant keywords such as "climate education", "science education", "environmental awareness", "climate change education", and "STEM education". Based on the criteria that have been set, as many as 27 scientific articles have been successfully identified and qualified for analysis in this study.

DISCUSSIONS AND RESULT
Inquiry and Project-Based Learning Approaches

The results of the analysis of various studies show that the inquiry-based learning (IBL) strategy is a very effective approach in integrating climate education into science learning, IBL encourages active involvement of students in the learning process through structured and exploratory scientific investigations, so as to be able to increase a deep understanding of environmental issues, especially climate change, Akaygun and Adadan (2020) emphasized that the application of the model Inquiry-based learning at the elementary school level significantly improves students' understanding of climate change, through hands-on experimental activities and real-world observation of environmental phenomena, students not only understand the theory, but also build scientific awareness of the dynamics of climate change around them, this approach has been proven to be able to foster curiosity, scientific thinking skills, and ecological awareness from an early age.

The IBL approach has developed in the form of design-based inquiry learning (DBIL), especially at the secondary education level. Brumann et al. (2022) developed DBIL as a model that integrates the design process with scientific exploration, providing space for students to be involved in the creation of concrete solutions to climate problems, DBIL emphasizes the importance of students' role in designing, evaluating, and revising solutions to complex and contextual climate issues, in practice students not only understand the theoretical concept of climate change, but also trained to apply it through prototypes, simulations, and experiments, this approach expands the scope of learning from mere comprehension to mastery of systemic, collaborative, and creative thinking skills in response to today's environmental challenges.

The problem-oriented project-based learning (POPBL) model shows promising results in the context of secondary education, Kundariati et al. (2025) report that this approach allows students to identify, analyze, and design solutions to local climate issues through problem-based project activities, with POPBL, students are invited to conduct field research, discuss critically, and present innovative solutions to environmental problems that are real in their communities, the results of the study show that this model is able to significantly improve students' critical thinking skills, while building environmental awareness and responsibility.

Integration of Technology in Climate Education

The development of educational technology provides a great opportunity for climate learning innovation, Chen et al. (2024) prove the effectiveness of Augmented Reality technology in improving students' understanding of aurora phenomena and climate science, AR technology allows the visualization of abstract concepts into more concrete and attractive visual representations.

Aulia et al. (2024) evaluated the use of the Climate Kids Interactive Web platform which has proven to be effective in building concept understanding and environmental awareness of grade VI students towards global warming materials, this interactive platform provides an engaging learning experience and facilitates the understanding of complex concepts through simulations and interactive activities.

AlQallaf et al. (2024) explore the potential of Virtual Reality in building empathy and awareness of climate change, the results of the study show that VR experiences are able to create strong emotional connections between students and environmental issues, increasing motivation to act proactively.

Kim et al. (2025) examined the role of STEM Makerspace in developing sustainability awareness through visualization and collaboration activities, collaborative and hands-on learning environments have proven to be effective in developing students' creative and innovative thinking skills in facing environmental challenges.

STEM and E-STEM Approach

The implementation of STEM (Science, Technology, Engineering, Mathematics) and E-STEM (Environmental STEM) approaches shows promising results in the context of climate education, Artika and Rosemary (2023) evaluated the application of E-STEM in building communities that are resilient to climate change in Aceh, with a focus on increasing students' awareness of local issues.

Maspul (2024) explores STEM education to address real-world climate change concerns and empower students as agents of change, this approach integrates science learning with the application of technology and engineering to develop innovative solutions to environmental problems.

Lestari et al. (2025) developed a STEM learning plan training program for climate change projects in physics learning for sustainable development, this program has proven to be effective in improving teachers' competence in integrating sustainability issues into the science curriculum.

School-University and Citizen Science Collaboration

Batchelder et al. (2023) evaluated school-university partnerships in climate and sustainability education projects in the UK, the results showed that citizen science and STEM approaches practically provide significant added value in climate learning, this collaboration allows access to wider resources and expertise, improving the quality of learning..

Forbes et al. (2020) explored the use of global climate models in high school science learning to improve climate literacy, this approach allows students to interact directly with scientific data and models used by professional researchers.

Model-Based Learning and Methodology Comparison

Bhattacharya et al. (2021) compared the effectiveness of model-based and non-model learning approaches in climate education in secondary schools, the results showed that model-based learning provides a deeper understanding of the climate system, but non-model approaches also have advantages in terms of student engagement and motivation.

Durak and Topçu (2024) developed a multifaceted approach to teaching climate change in secondary schools, integrating various learning strategies to accommodate the complexity of the topic, this approach proved effective in improving students' comprehensive understanding of climate issues.

Integration of Social and Humanities Aspects

Lasker and Lovitt (2024) developed a humanization approach to climate change education by integrating social sciences, humanities, UN SDGs, and systems thinking in chemistry learning. This approach emphasizes the importance of the social and ethical dimensions in understanding climate issues.

Lovitt et al. (2025) explore the integration of narrative, storytelling, and embodied learning in climate change education, this approach has proven effective in creating emotional connections and increasing student motivation to act.

Liu (2024) develops an innovative approach in undergraduate level climate education through future exploration and narrative, this method allows students to develop realistic future visions and scenarios based on an understanding of climate science.

Critical Awareness Development and Positive Engagement

Clark (2024) emphasizes the importance of developing critical climate awareness as a science education outcome, this concept includes not only cognitive understanding but also the ability to critically analyze climate information and develop appropriate responses.

Gal (2024) researched strategies to encourage positive engagement and environmental activism in grade VI, the results of the study showed that approaches that emphasized agency and student empowerment were more effective in developing long-term commitments to climate action.

Kang and Tolppanen (2024) explore the role of science education as a catalyst to increase students' willingness to take climate action, this study shows that effective science education can be a driving force for changes in students' behaviors and attitudes.

Innovation in Learning Methodologies and Instruments

Bethânia and Rita (2024) developed a creative approach by integrating art into meteorology education for elementary school students through the creation of weather instruments, this approach has proven to be effective in increasing conceptual understanding as well as developing students' creativity. Asimakopoulou et al. (2023) explore the use of Earth Observation as a climate change education approach for newcomers in schools, Earth observation technology provides access to real-time data and visualizations that enable contextual learning.

Hijazi et al. (2025) evaluated climate literacy for higher education students through a case study at the University of the West of England. This research provides insights on the development of climate curriculum at the university level.

Table 1. Key Findings

Approach Categories	Researchers	Methods/Strategies	Main Impact
Inquiry-Based Learning	Akaygun & Adadan (2020)	Inquiry-based learning	Improving the understanding of climate change for elementary school students
	Brumann et al. (2022)	Design-based inquiry learning	Understanding the complexity of climate issues in high school
Project-Based Learning	Kundariati et al. (2025)	Problem-oriented PBL	Increased critical thinking and environmental awareness
Technology Integration	Chen et al. (2024)	Augmented Reality	Visualization of abstract concepts into concrete
	Aulia et al. (2024)	Platform Climate Kids	Increased understanding of global warming
	AlQallaf et al. (2024)	Virtual Reality	Building empathy for climate change
STEM/E-STEM	Artika & Rosemary (2023)	E-STEM approach	Climate awareness in the local context of Aceh
	Maspul (2024)	STEM education	Empowering students as agents of change
Institutional Collaboration	Batchelder et al. (2023)	School-university partnership	Improved climate practical learning
	Forbes et al. (2020)	Global climate models	Climate literacy through scientific models
Model-Based Learning	Bhattacharya et al. (2021)	Model-based learning	In-depth understanding of the climate system
A Holistic Approach	Lasker & Lovitt (2024)	Social-humanities integration	Humanization of climate education
	Liu (2024)	Future narrative exploration	Realistic vision development
Critical Awareness	Clark (2024)	Critical climate awareness	Critical analysis of climate information

15

Approach Categories	Researchers	Methods/Strategies	Main Impact
	Gal (2024)	Environmental activism	Positive engagement and long-term commitment

Table 1 presents a summary of the main findings that have been discussed in the results and discussion section, this table summarizes the learning approaches, the researchers who studied, the methods/strategies used, and the main impacts on climate learning, this table is very helpful for readers to quickly understand various models of climate education integration that have proven effective, as well as showing the variety of approaches that can be adapted at different levels of education.

CONCLUSION

Based on a systematic literature review of 27 scientific articles published between 2020-2025, this study identifies various effective approaches in integrating climate education into science learning, the main findings show that inquiry-based learning and project-based learning approaches are proven to be most effective in improving students' understanding and awareness of climate, the integration of technologies such as Augmented Reality, Virtual Reality, and learning platforms Interactive has a significant impact on visualizing abstract concepts and increasing student engagement.

The STEM and E-STEM approaches show success in developing students' critical and innovative thinking skills in facing environmental challenges, collaboration between schools and universities through citizen science programs has been proven to provide added value in practical learning on climate issues, learning that integrates social and humanities aspects has successfully created strong emotional connections and increased students' motivation to act proactively.

The development of critical climate awareness is an important outcome of science education that not only enhances cognitive knowledge but also critical analysis skills and appropriate responses to climate information, an approach that emphasizes agency and student empowerment has proven to be more effective in developing long-term commitments to climate action.

The implications of this study emphasize the need to transform the science curriculum to be more contextual and environmentally oriented, the integration of climate education in science learning must be carried out systematically by considering the cognitive, affective, and psychomotor aspects of students, and the professional development of teachers in implementing these innovative approaches is the key to the success of climate education programs in schools.

This research provides a theoretical contribution in the development of a framework for integrating climate education in science learning, as well as a practical contribution in the form of recommendations for learning strategies that have been proven to be effective, these findings can be a reference for education practitioners, policymakers, and researchers in developing comprehensive and sustainable climate education programs.

REFERENCES

Akaygun, S., & Adadan, E. (2020). Fostering senior primary school students' understanding of climate change in an inquiry-based learning environment. Education 3-13, 49, 330 - 343. https://doi.org/10.1080/03004279.2020.1854961

AlQallaf, N., Elnagar, D., Aly, S., Elkhodary, K., & Ghannam, R. (2024). Empathy, Education, and Awareness: A VR Hackathon's Approach to Tackling Climate Change. Sustainability. https://doi.org/10.3390/su16062461

Artika, W., & Rosemary, R. (2023). Environmental STEM (E-STEM) in Building Climate-Resilient Communities in Aceh: Students' Awareness. Jurnal Penelitian Pendidikan IPA. https://doi.org/10.29303/jppipa.v9i8.4970

Asimakopoulou, P., Nastos, P., Vassilakis, E., Antonarakou, A., Hatzaki, M., Katsigianni, O., Papamatthaiou, M., & Kontoes, C. (2023). Climate Change Education through Earth Observation: An Approach for EO Newcomers in Schools. Sustainability. https://doi.org/10.3390/su151914454

Asimakopoulou, P., Nastos, P., Vassilakis, E., Hatzaki, M., & Antonarakou, A. (2021). Earth Observation as a Facilitator of Climate Change Education in Schools: The Teachers' Perspectives. Remote. Sens., 13, 1587. https://doi.org/10.3390/RS13081587

Aulia, I., Sujana, A., & Sunaengsih, C. (2024). Application of the Climate Kids Interactive Web to Build Understanding of Concepts and Environmental Awareness of Class VI Students on Global Warming Material. Jurnal Penelitian Pendidikan IPA. https://doi.org/10.29303/jppipa.v10i1.6386

Batchelder, M., Swinney, M., O'Hara, T., Goddard, A., Lewis, E., Cox, J., & Fowler, H. (2023). Experiences from a School–University Partnership Climate and Sustainability Education Project in England: The Value of Citizen Science and Practical STEM Approaches. Sustainability. https://doi.org/10.3390/su15129401

Bethânia, S., & Rita, R. (2024). Crafting weather instruments: integrating art into meteorological education for elementary students. International conference Czech republic and lusophonic countries 2024. https://doi.org/10.24132/zcu.2024.12426.76-77

Bhattacharya, D., Steward, K., & Forbes, C. (2021). Climate education in secondary science: comparison of model-based and non-model-based investigations of Earth's climate. International Journal of Science Education, 43, 2226 - 2249. https://doi.org/10.1080/09500693.2021.1958022

Brumann, S., Ohl, U., & Schulz, J. (2022). Inquiry-Based Learning on Climate Change in Upper Secondary Education: A Design-Based Approach. Sustainability. https://doi.org/10.3390/su14063544

Chen, S., Lin, P., Lai, Y., & Liu, C. (2024). Enhancing Education on Aurora Astronomy and Climate Science Awareness through Augmented Reality Technology and Mobile Learning. Sustainability. https://doi.org/10.3390/su16135465

Clark, H. (2024). Critical climate awareness as a science education outcome. Science Education. https://doi.org/10.1002/sce.21896

Durak, B., & Topçu, M. (2024). Navigating complexity: a multifaceted approach to teaching climate change in middle school. Science Activities, 61, 163 - 179. https://doi.org/10.1080/00368121.2024.2362161

Forbes, C., Chandler, M., Bhattacharya, D., Steward, K., Blake, J., Johnson, V., Morrow, M., Mason, W., & DeGrand, T. (2020). Fostering climate literacy with global climate models in secondary science classrooms. **, 29-43. https://doi.org/10.4324/9780367179496-3

Gal, A. (2024). Fostering positive engagement: climate change and environmental activism in the sixth-grade classroom. Environmental Education Research, 30, 2272 - 2290. https://doi.org/10.1080/13504622.2024.2369804

Hijazi, R., Hijazi, A., & Jones, V. (2025). Climate literacy for students in higher education: a case study from the University of the West of England (UWE), Bristol, in the

United Kingdom. International Journal of Sustainability in Higher Education. https://doi.org/10.1108/ijshe-07-2024-0455

Illahaqi, A., Nurcahyo, H., & Panjaitan, M. (2021). Advancing Students' Environmental Sustainability Awareness Through Science Mobile Learning: A Literature Review. Proceedings of the 6th International Seminar on Science Education (ISSE 2020). https://doi.org/10.2991/ASSEHR.K.210326.114

Kang, J., & Tolppanen, S. (2024). Exploring the role of science education as a catalyst for students' willingness to take climate action. International Journal of Science Education. https://doi.org/10.1080/09500693.2024.2393461

Kim, J. (2024). Exploring Climate Change through Experiential Learning Activities for Nonscience Majors. Journal of Chemical Education. https://doi.org/10.1021/acs.jchemed.4c00181

Kim, M., Markle, J., Jin, Q., & Akdemir, K. (2025). Children's Visualization and Collaboration in a STEM Makerspace: Opportunities for Fostering Sustainability Awareness. Sustainability. https://doi.org/10.3390/su17052014

Kumar, P., Sahani, J., Rawat, N., Debele, S., Tiwari, A., Emygdio, A., Abhijith, K., Kukadia, V., Holmes, K., & Pfautsch, S. (2023). Using empirical science education in schools to improve climate change literacy. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2023.113232

Kundariati, M., Ibrohim, I., Rohman, F., & Nida, S. (2025). Navigating climate change education: a problem-oriented project-based learning in secondary schools. Science Activities, 62, 156 - 170. https://doi.org/10.1080/00368121.2025.2463653

Lasker, G., & Lovitt, C. (2024). From Science to Society: Humanizing Climate Change Education by Integrating the Social Sciences and Humanities, U.N. SDGs, and Systems Thinking in Chemistry Learning. Journal of Chemical Education. https://doi.org/10.1021/acs.jchemed.4c00460

Lestari, N., Jatmiko, B., Hariyono, E., Dwikoranto, D., & Prahani*, B. (2025). Training on Lesson Plan of Climate Change STEM Project in the Physics Learning for Sustainable Development. A Journal of Community Service. https://doi.org/10.20527/btjpm.v7i1.13439

Liu, S. (2024). Exploring and narrating futures in undergraduate climate change education: an innovative teaching approach. International Journal of Sustainability in Higher Education. https://doi.org/10.1108/ijshe-08-2023-0336

Lovitt, C., Bertram, M., Campbell, D., Shinneman, A., Groom, M., Hathaway, D., Lambert, A., & Lasker, G. (2025). Embodying Change: Courses that Integrate Narrative, Storytelling, and Embodied Learning in Climate Change Education. Journal of Chemical Education. https://doi.org/10.1021/acs.jchemed.4c00465

Maspul, K. (2024). Exploring STEM Education for Real-World Climate Change Concerns to Empower Students as Change Agents. Journal of Physics Education and Science. https://doi.org/10.47134/physics.v1i2.249.