

## **Innovative Teaching Methods in Climate Change Education: A Shift from Theory to Experiential Learning**

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### **Abstract**

*Climate change education has emerged as a critical component of contemporary pedagogy; yet, traditional theory-focused approaches often fail to engage learners effectively or facilitate meaningful behavioural change. This research paper examines the shift from conventional teaching methods to experiential learning approaches in climate change education across diverse educational contexts. Through a comprehensive review of current literature and empirical studies, this paper demonstrates that experiential, place-based, and interactive pedagogies significantly enhance student understanding, engagement, and commitment to climate action. Key findings reveal that hands-on activities, virtual reality applications, gamification, community engagement, and transgressive pedagogies foster deeper cognitive learning, emotional attachment, and pro-environmental behaviours. However, implementation challenges, including resource constraints, gaps in teacher preparation, and barriers to curriculum integration, persist. This paper concludes that a strategic integration of experiential learning methodologies, supported by institutional commitment and adequate resources, can transform climate change education from passive knowledge acquisition to active, transformative learning that empowers students as agents of sustainable change.*

**Keywords:** Climate change education, Experiential learning, Pedagogical innovation, Sustainability, Student engagement, Transformative learning

### **Introduction**

Climate change represents one of the most pressing challenges facing humanity in the twenty-first century, necessitating urgent and comprehensive educational responses. The global scientific community has established with near certainty that anthropogenic climate change is occurring and requires immediate mitigation and adaptation strategies. Yet, despite this consensus and growing global recognition of the climate crisis, traditional educational systems continue to rely heavily on theory-focused paradigms that prioritize economic growth and abstract knowledge transfer over practical application and behavioral transformation (Manteaw et al., 2025). This disconnect between educational content and real-world action has prompted educational researchers and practitioners to advocate for fundamental shifts in how climate change is taught and learned.

Traditional lecture-based instruction in climate education typically emphasises the transmission of scientific facts and data about climate mechanisms, greenhouse gas emissions, and projected future scenarios. While such foundational knowledge remains important, research increasingly demonstrates that this approach alone is insufficient to motivate students to understand the urgency of climate challenges or to develop the competencies necessary for meaningful climate action (Pratama, 2025). Furthermore, conventional pedagogies often fail to

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engage learners emotionally or to connect abstract scientific concepts to the lived experiences and local contexts of students, thereby limiting the development of environmental stewardship and social change agency.

In response to these limitations, educators and institutions worldwide have begun experimenting with alternative pedagogical approaches that emphasise active engagement, experiential learning, community participation, and place-based education. These innovative methods aim to bridge the gap between theoretical knowledge and practical application, fostering not only cognitive understanding but also emotional investment and behavioural commitment. Research on these emerging approaches suggests that experiential learning methodologies can significantly enhance climate literacy, cultivate environmental consciousness, and empower students to become active participants in sustainable development (Muccione et al., 2025).

The imperative for this educational shift is multifaceted. First, climate change is fundamentally a complex, transdisciplinary phenomenon that cannot be adequately addressed through siloed, discipline-specific instruction. Second, addressing climate challenges requires not merely informed citizens but active change agents equipped with problem-solving skills, critical thinking abilities, and collaborative competencies. Third, mounting evidence suggests that experiential and emotionally engaging pedagogies yield more enduring learning outcomes and behavioural changes than passive knowledge transmission. Fourth, educational institutions have a unique opportunity and responsibility to position themselves as catalysts for societal transformation toward sustainability.

## Objectives

This research paper pursues the following objectives:

1. To examine the theoretical foundations and empirical evidence supporting the shift from theory-focused to experiential climate change education.
2. To identify and analyse innovative teaching methods and pedagogical approaches employed in climate change education.
3. To assess the impact of experiential learning approaches on multiple dimensions of student development.
4. To explore the enabling conditions and critical success factors that facilitate the effective implementation of experiential climate change education.
5. To identify and analyse barriers and challenges to the widespread adoption of experiential pedagogies in climate change education.
6. To synthesise findings and recommendations to guide educators, curriculum developers, policymakers, and institutional leaders in designing and implementing effective, evidence-based climate change education programs that harness the transformative potential of experiential learning.

## Theoretical Foundations of Experiential Learning in Climate Education

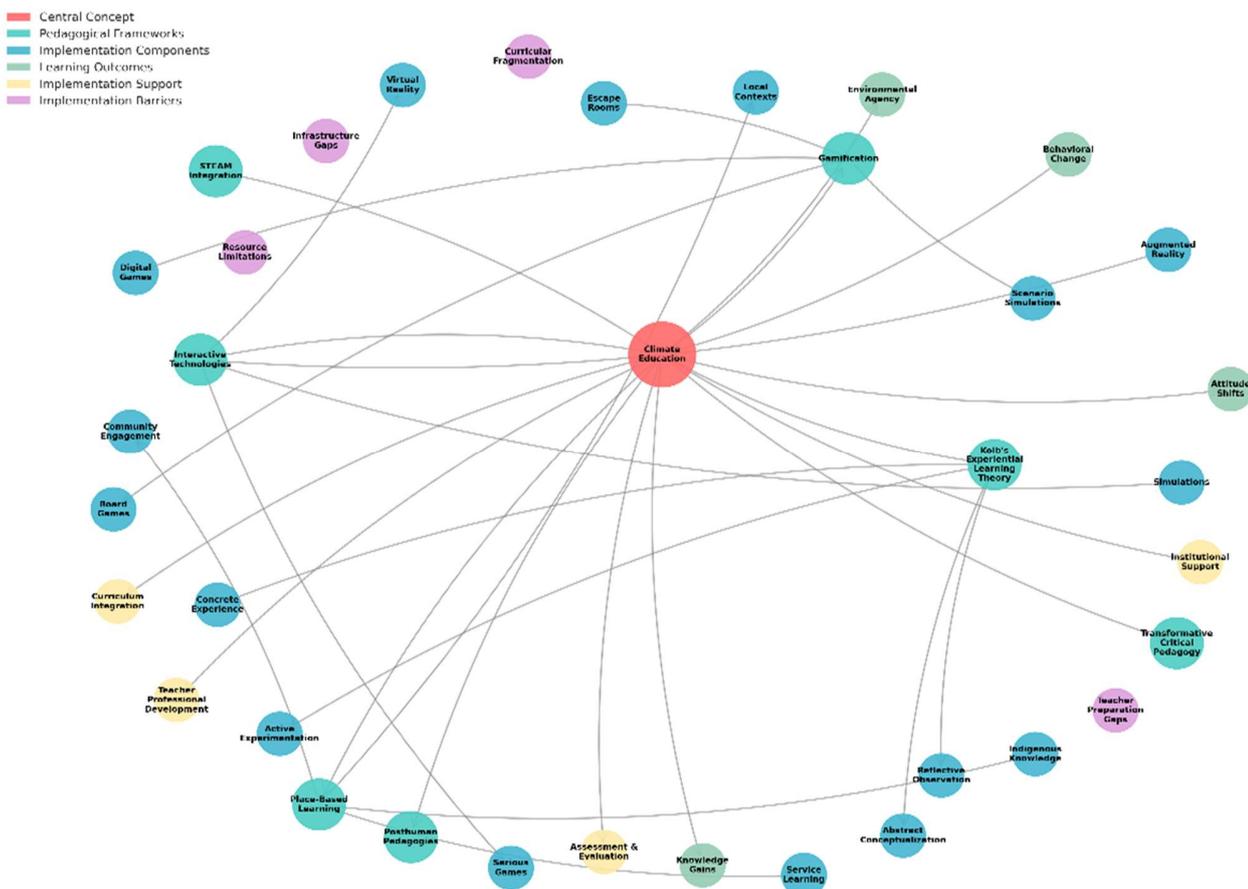
Experiential learning theory provides a robust theoretical framework for understanding how climate change education can transition from passive knowledge transmission to active, transformative engagement. Kolb's Experiential Learning Theory (ELT), which encompasses concrete experience, reflective observation, abstract conceptualisation, and active experimentation, offers a structured approach to designing pedagogically sound climate education activities (Delamontano et al., 2025). This cyclical model emphasises that meaningful learning occurs through direct engagement with phenomena, followed by reflection on those experiences, integration into broader conceptual frameworks, and application in new contexts.

The application of ELT to climate education suggests that students must move beyond classroom lectures to engage in concrete experiences with environmental systems, local communities affected by climate impacts, and

sustainability solutions. Field learning journeys to environmentally significant locations, for instance, provide students with direct sensory experiences and opportunities to witness climate-related challenges firsthand, thereby grounding abstract scientific concepts in tangible reality. Research on such place-based approaches in Ghana demonstrated marked positive changes in students’ attitudes toward climate change and sustainability learning, enhanced orientation for environmental stewardship and social change advocacy, and improved dispositions and competencies for partnerships and collaborations in addressing socioecological challenges (Manteaw et al., 2025).

Beyond cognitive dimensions, contemporary climate education research emphasises the critical importance of emotional engagement and the development of what scholars term “environmental imagination”-the capacity to envision alternative futures and to recognise one's agency in creating sustainable communities (Sarkar, 2024). Traditional theory-focused instruction often fails to cultivate this emotional and imaginative dimension, potentially resulting in what some educators describe as “climate anxiety” or learned helplessness rather than empowered agency. Experiential pedagogies that facilitate emotional connection to places, people, and ecosystems can foster more resilient, hope-oriented responses to climate challenges.

**Comprehensive Framework of Climate Education Approaches and Theoretical Foundations**



**Figure 1: Theoretical Foundations of Experiential Learning in Climate Education**

## **Place-Based and Community-Engaged Learning**

One of the most promising approaches emerging in climate change education is place-based learning, which grounds educational activities in the local environmental, social, and cultural contexts of students. Place-based education recognises that meaningful learning occurs when students understand the connections between their own communities and global systems, and when they participate in addressing real challenges affecting their localities. This approach honors indigenous knowledge systems, local ecological understanding, and community-specific vulnerabilities and adaptive strategies.

Research demonstrates that place-based climate education yields significant benefits. Studies in both urban and rural settings have shown that when students engage in analysing the socio-territorial reality of their own municipalities, assessing local sustainability challenges, and designing place-appropriate strategies for sustainable development, they develop deeper environmental knowledge, an increased sense of agency, and stronger commitment to environmental conservation (Correa et al., 2025). Such approaches also foster what scholars describe as ‘critical place consciousness’—an understanding of how local environmental conditions reflect and are shaped by broader social, economic, and political systems.

Community engagement and participatory approaches further enhance the effectiveness of place-based climate education. When educational activities involve direct collaboration with community members, local environmental organisations, municipal authorities, and affected populations, students gain exposure to diverse perspectives, develop communication and negotiation skills, and understand that climate solutions require multi-stakeholder collaboration. Research on youth climate councils established in European cities revealed that when young people co-developed sustainability proposals and engaged with municipal authorities, they demonstrated significant learning gains and developed increased sense of civic efficacy and environmental stewardship (Senese et al., 2025).

The integration of service learning, in which students undertake credited projects benefiting targeted communities while addressing climate change issues, represents another powerful variant of community-engaged climate education. This approach directly addresses what educators identify as the “knowing-doing gap,” wherein students may possess significant climate knowledge yet fail to translate such knowledge into meaningful action or behavioural change. By engaging in tangible service to communities, students develop not only theoretical understanding but practical competencies and intrinsic motivation for continued climate action (Mohamad et al., 2024).

## **Interactive Technologies and Virtual Experiences**

While experiential learning has traditionally emphasised direct, physical engagement with environments and communities, emerging research demonstrates the significant pedagogical potential of interactive technologies in extending and enriching climate education. Virtual reality (VR), augmented reality (AR), simulation platforms, serious games, and mobile learning applications can provide immersive, learner-centered experiences that facilitate deeper cognitive learning, greater emotional attachment to climate issues, and informed behaviour change (Vesna, 2025).

VR applications, in particular, enable students to visualise complex climate processes, evaluate the effects of human actions through simulation, and test mitigation and adaptation strategies in risk-free environments. A three-day VR hackathon involving engineering students designing immersive environments addressing sustainable development goals revealed that this innovative approach significantly enhanced students' understanding of climate issues and the SDGs, developed their competency with VR technologies, and improved teamwork and problem-solving skills (AlQallaf et al., 2024). The immersive nature of VR environments appears to create

stronger emotional engagement with climate content than traditional media, potentially overcoming the affective barriers that impede climate action in face-to-face educational contexts.

Gamification-the application of game design principles to educational contexts-has also emerged as a promising approach to climate education. Board games and digital games that incorporate climate dynamics, energy-carbon nexus concepts, and real-world climate impacts can enhance engagement and influence student attitudes toward sustainability (GonzalezLpez et al., 2025). Game-based learning structures appear particularly effective in creating “cognitive dissonance” that motivates students to reconsider their assumptions about energy use, development, and environmental protection. Research with graphic design students in Ghana using game-based experiential learning approaches revealed that 27 of 75 students came to recognise graphic design as a viable tool for promoting environmental sustainability, demonstrating how gaming can facilitate perspective transformation (Opoku-Asare et al., 2025).

Despite the evident benefits of interactive technologies, several barriers to their widespread implementation remain. Access gaps, technological infrastructure requirements, content validity concerns, and the necessity for educator training and curriculum alignment present ongoing challenges (Vesna, 2025). Nevertheless, when interactive technologies are integrated as part of evidence-based pedagogical practices rather than as ends in themselves, they can significantly contribute to climate literacy and empower students to play active roles in sustainability activities.

### **Gamification and Game-Based Learning**

Gamification represents a distinct pedagogical strategy that harnesses the motivational and cognitive benefits of game mechanics and game design to enhance learning engagement and outcomes. Beyond virtual reality applications, board games, serious games, scenario simulations, and escape room games have all been adapted for climate and disaster education contexts (Bai et al., 2024). These approaches create psychologically “safe spaces” for experiential learning in which students can make decisions, experience consequences, collaborate with peers, and reflect on learning without the risks associated with real-world climate and disaster scenarios.

The Raising Climate Heroes: Ecological Game Camp, a mixed-methods study examining game-based experiential climate education with both primary school students and adults, revealed significant increases in climate-related knowledge, awareness, climate-friendly behaviour, and hope, coupled with reductions in climate anxiety (Demir Yıldız, 2025). Qualitative findings indicated high participant satisfaction, demonstrating how combining cognitive and emotional elements through play and hands-on learning can effectively promote pro-environmental attitudes. The activities most favoured by participants-such as ecological experiments, composting, and collaborative cooking-shared common characteristics of tangibility, immediate observable outcomes, and collaborative engagement.

Research on gamification in disaster education involving 1,744 participants across multiple countries identified seven categories of game-based approaches, ranging from tabletop games to escape room games (Bai et al., 2024). The diversity of game formats demonstrates the flexibility and adaptability of game-based learning to different educational levels, content domains, and learning objectives. Importantly, gamification appears particularly effective when combined with rigorous content, clear learning objectives, and authentic assessment mechanisms rather than when games are employed superficially or as motivational “sugar coating” for passive learning.

### **STEAM Integration and Interdisciplinary Approaches**

Science, Technology, Engineering, and Mathematics (STEAM) education that incorporates the arts and emphasises integration across traditional disciplinary boundaries has emerged as a promising framework for

climate change education. By integrating climate content across multiple disciplines and involving students in applying scientific knowledge to authentic environmental and engineering challenges, STEAM approaches foster the development of complex problem-solving competencies and systemic thinking skills essential for addressing climate change.

Research examining the impact of a climate change STEAM education program on environmental competence among second graders revealed significant gains in environmental information literacy and creative problem-solving, with benefits extending across multiple domains of environmental competence (Keum & Baek, 2025). Despite elementary students' limited formal science background, the integration of experiential, hands-on STEAM activities enabled meaningful engagement with climate concepts and fostered emerging environmental awareness and small-scale climate actions. Teacher observations and student interviews revealed greater engagement than typically observed with traditional instruction, suggesting that integrated, multimodal approaches resonate with younger learners' cognitive and developmental characteristics.

STEM education that explicitly addresses real-world climate change concerns and involves community-based project engagement can further enhance student motivation and the relevance of learning. When students engage in community-based STEM projects addressing climate mitigation, adaptation, or environmental remediation, they develop critical thinking skills, problem-solving abilities, and environmental stewardship while experiencing the practical application of academic content (Maspul, 2024). The integration of STEM education with community involvement and climate change appears to create particularly powerful learning experiences that simultaneously develop academic competencies and pro-environmental dispositions.

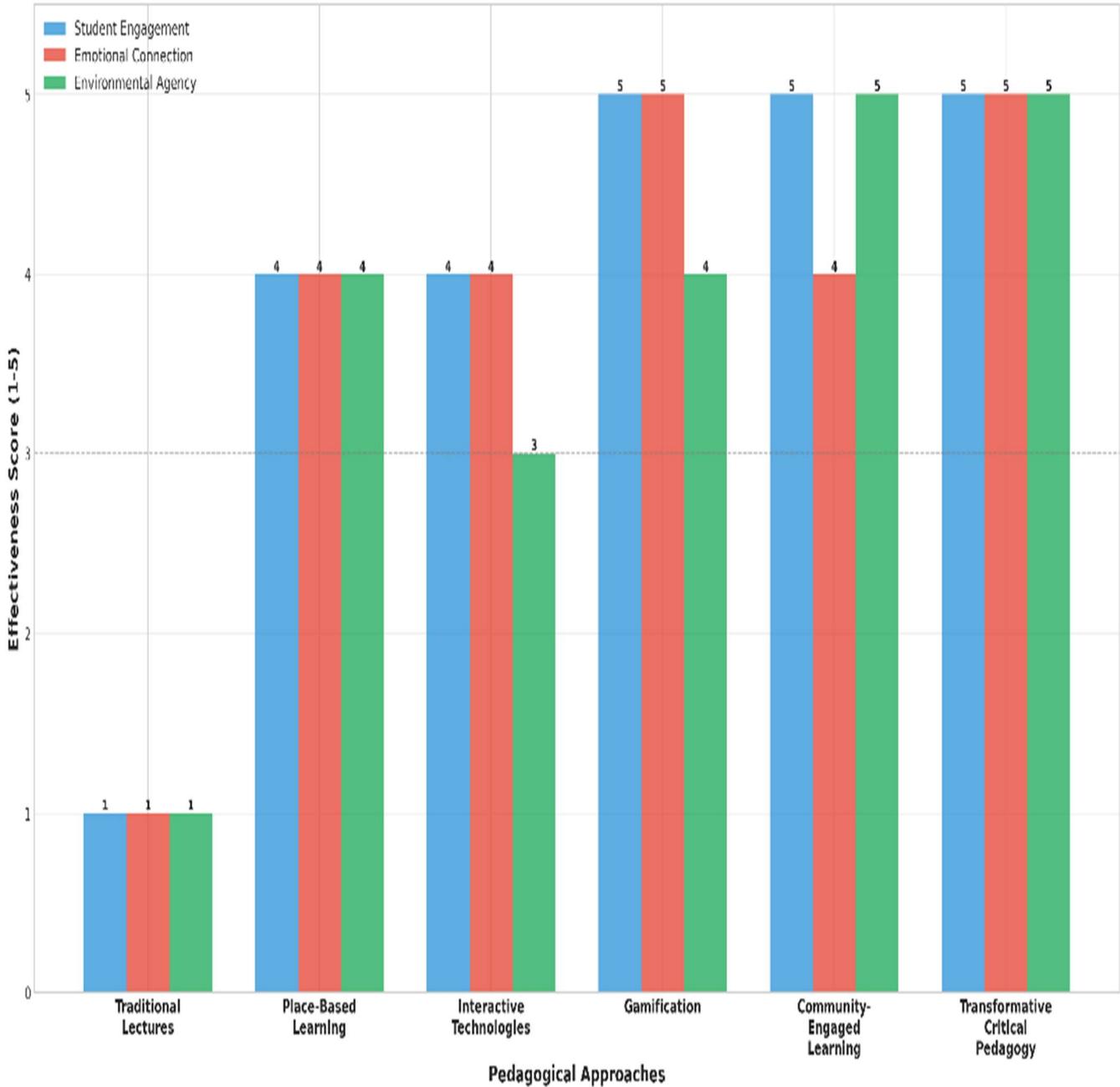
### **Professional Development and Teacher Preparation**

The successful implementation of experiential and innovative climate change education approaches is inextricably linked to the preparation, professional development, and ongoing support of educators. Research reveals that teachers' own knowledge about climate change, their attitudes and beliefs regarding climate science and solutions, and their confidence in teaching about climate issues significantly influence their pedagogical choices and their capacity to inspire students toward climate action (Nguyen et al., 2025). Yet many pre-service and in-service teachers possess limited climate knowledge, ambiguous or inconsistent beliefs about climate change, and insufficient preparation to teach about these complex, urgent issues (Nguyen et al., 2025).

Comprehensive teacher professional development programs that incorporate experiential learning, outdoor and place-based learning, collaborative learning, culturally relevant teaching, sociopolitical perspectives, and emotional responsiveness appear most effective in developing teachers' capacities to deliver high-quality climate education (Bascop et al., 2025). Research analysing teacher-created educational materials within CPD programs revealed the presence of key elements for effective professional development, including active learning, collaborative engagement, and integration with teachers' local environmental contexts. Importantly, teachers themselves identified the need for transdisciplinary integration and contextualised education approaches in their own CPD experiences.

Universities and educational institutions have a particular responsibility and opportunity to serve as hubs for climate change education development and implementation. When universities facilitate community-engaged climate projects through structured grant programs that prioritise partnerships, equity, diversity, inclusion, and accessibility, and experiential learning opportunities, they can simultaneously support faculty and student development while addressing community-identified climate challenges (Eirikson & Haddock, 2025). Such institutional approaches position universities not merely as research centres but as catalysts for community-engaged climate action.

**Comparative Effectiveness of Climate Education Pedagogical Approaches  
Across Key Learning Dimensions**



**Figure 2:** Comparative effectiveness of climate education: pedagogical approaches

**Assessment and Evaluation of Learning Outcomes**

A critical dimension often overlooked in discussions of innovative climate education is the assessment and evaluation of learning outcomes. Research emphasises the importance of developing assessment approaches that

measure not merely cognitive knowledge gains but also shifts in attitudes, values, behaviours, and sense of environmental agency. The reflect rubric, for instance, enables educators to assess whether students have achieved critical reflection on climate content, connecting concepts to individual experiences, institutional practices, and public health and policy implications (Dalapati et al., 2024). Medical students participating in a curricular thread on climate change, health, and equity who completed critical reflection essays demonstrated 100% capability in identifying new areas of medical knowledge and connecting concepts to broader systems; 90% expressed emotionally laden sentiments about climate issues; and 80% identified actionable items at multiple levels, from personal behaviour change to policy advocacy.

Authentic assessment approaches that evaluate student learning through demonstration of competencies in real-world contexts, such as the Making Cities Resilient assessment activity in which graduate students conduct comprehensive urban resilience evaluations using the UNDRR's framework and present findings with recommendations to community stakeholders, provide evidence that students can successfully apply climate concepts to tangible problems (Oreta, 2025). Such assessments measure not merely knowledge retention but the development of practical competencies and the capacity to bridge theory and practice in addressing complex environmental challenges.

### **Challenges and Barriers to Implementation**

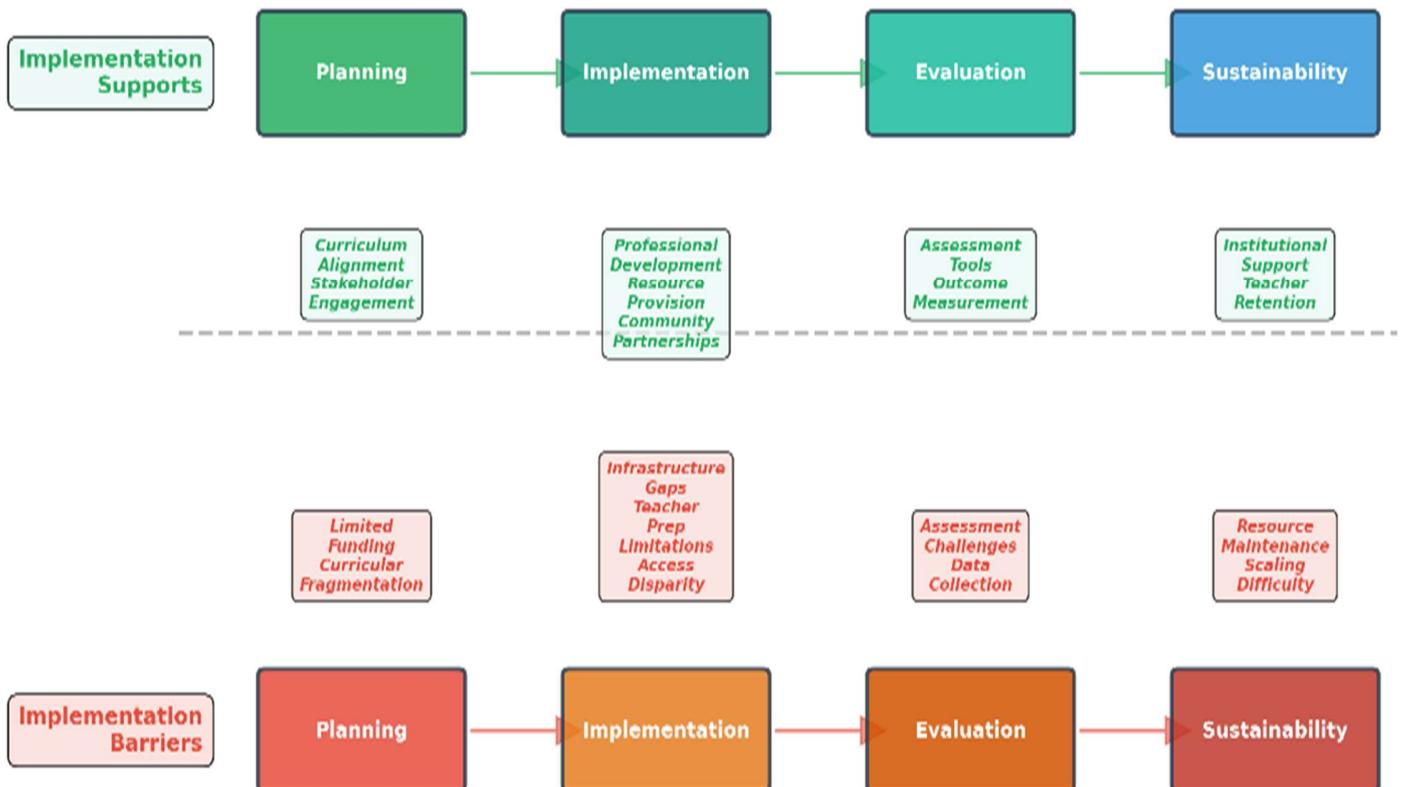
Despite accumulating evidence of the effectiveness of experiential climate education approaches, significant barriers to their widespread adoption persist. Limited financial and material resources, insufficient teacher training and preparation, curricular fragmentation and competing priorities, and insufficient institutional support represent systemic barriers affecting schools globally (Suarlin, 2023). In lower-income regions and schools serving disadvantaged populations, barriers including inadequate technological infrastructure, limited access to transportation for field-based learning, and competing demands on instructional time present particular challenges.

Access gaps and technological infrastructure requirements present specific barriers to the implementation of interactive and technology-enhanced climate education approaches (Vesna, 2025). While VR, AR, and game-based applications offer significant pedagogical potential, their cost and technical requirements limit accessibility in resource-constrained educational contexts. Additionally, the rapid pace of technological change necessitates ongoing educator training and curriculum updates to ensure that interactive technologies remain pedagogically sound and aligned with learning objectives rather than serving primarily as motivational novelties.

Curricular constraints and the fragmentation of climate content across multiple subjects without explicit integration represent additional barriers. Research across five countries revealed that while policymakers, teacher professional development providers, and teachers generally agreed on the importance of climate education and the value of active learning pedagogies, they differed in their conceptualisations of climate knowledge and the appropriate curriculum locations and pedagogical approaches (Ben Zvi Assaraf et al., 2025). In all five countries studied, interviewees called for explicit curricular connections to climate change and for governmental leadership in supporting the implementation of climate education, resource provision, and professional development.

Furthermore, the need to balance scientific rigour with emotional engagement and to avoid either minimising climate urgency or fostering debilitating climate anxiety presents ongoing pedagogical challenges (Huser et al., 2025). Some educators and institutions have begun experimenting with ludic pedagogies that incorporate solutions-based frameworks, serious games, flipped classroom models, and community connections to deliver climate and sustainability education, while fostering what some describe as “joyful learning” rather than anxiety-inducing pedagogy.

**Climate Education Implementation Pathway:  
Supports and Barriers Across Project Phases**



**Figure 3:** Challenges and Barriers to Implementation of Climate Education

## **Transformative and Critical Approaches**

Beyond experiential learning narrowly conceived, some educators and scholars advocate for explicitly transformative and critical pedagogical approaches to climate education. Drawing on Freirean traditions, these approaches emphasise dialogue, criticality, creativity, and the development of what Freire termed “conscientization”—the development of critical consciousness regarding systemic inequities and the possibilities for social transformation (Caceres et al., 2024). Such approaches recognise that climate change is not merely a scientific or technical problem but fundamentally a social, political, and ethical challenge rooted in systems of inequality and exploitation.

Transformative climate education aims not merely to convey knowledge or to develop individual behaviours but to foster what scholars describe as “social change agency”—the capacity and commitment to work collectively toward structural transformations in economic, social, and political systems (Khalo & Damoah, 2023). Research on transgressive pedagogies grounded in local communities, place-based approaches, and critical examination of structural inequities demonstrates their capacity to cultivate environmental stewardship, social change advocacy, and collaborative problem-solving skills (Manteaw et al., 2025). These approaches appear particularly promising in fostering what some educators term “environmental justice” perspectives that connect climate challenges to broader systems of social and economic inequality.

Posthuman pedagogies represent an emerging framework that challenges anthropocentric assumptions in environmental education and recognises the relational and material connections between humans and the more-than-human world (Jordan & Jansson, 2024). Rather than viewing climate change as a problem requiring human technological solutions, posthuman approaches invite students to examine relationships with non-human entities, to understand human continuity with ecological systems, and to recognise the agency and value of more-than-human beings. Such approaches may foster more ecologically grounded environmental ethics and less instrumentalist orientations toward nature and other species.

## **Conclusion**

The accumulated evidence presented in this review demonstrates compellingly that climate change education is undergoing a fundamental and necessary transformation from theory-focused, lecture-based instruction toward experiential, place-based, community-engaged, and technologically-enhanced pedagogies. This shift reflects both theoretical advances in understanding learning processes and the urgent recognition that passive knowledge transmission is insufficient to foster the knowledge, skills, attitudes, and behaviours required for meaningful climate action at individual and systemic levels.

Experiential learning approaches-encompassing place-based education, community engagement, service learning, field-based activities, and hands-on investigations-have been demonstrated across multiple educational levels and geographic contexts to enhance climate literacy, foster emotional connection to environmental issues, develop environmental stewardship orientation, and cultivate commitment to climate action. Interactive technologies, including virtual reality, augmented reality, and gamification, can extend the reach and enhance the engagement potential of experiential approaches, particularly for learners unable to access direct field experiences. STEAM integration and interdisciplinary approaches facilitate the development of complex problem-solving competencies and systemic thinking skills essential for addressing climate challenges.

However, the widespread transformation of climate change education practice requires addressing multiple systemic barriers. Investment in comprehensive professional development that equips teachers with both climate content knowledge and innovative pedagogical competencies is essential. Curricular integration and explicit

alignment of climate education with educational standards and learning objectives must be accompanied by institutional commitment and resource allocation. Policymakers at national and subnational levels must provide leadership in mandating climate education integration, providing resources, and supporting educators. Universities and educational institutions must position themselves as hubs for climate change education development and community engagement, simultaneously modelling sustainable practices and conducting rigorous research on pedagogical effectiveness.

Critically, the transition to experiential climate education must be accompanied by explicit attention to equity, accessibility, and social justice. Experiential approaches must be designed to ensure that all students-including those in resource-constrained contexts, students with disabilities, and students from marginalized communities-have meaningful opportunities to engage with climate content through multiple modalities. Furthermore, climate education must explicitly address how climate impacts and solutions are distributed inequitably across different populations, and how addressing climate change requires confronting systemic inequalities and injustices.

Future research should investigate long-term outcomes of experiential climate education approaches, comparing cohorts of students who have engaged in innovative pedagogies with those receiving traditional instruction to determine whether experiential approaches produce more durable behavioural and attitudinal changes. Research should also examine how experiential climate education approaches can be effectively adapted and implemented in diverse cultural, geographic, and socioeconomic contexts, honouring local knowledge systems and addressing context-specific climate vulnerabilities and adaptation strategies.

In conclusion, the convergence of theoretical advances in learning science, accumulating empirical evidence of pedagogical effectiveness, and the urgent imperative to foster informed, engaged, and empowered citizens capable of climate action creates a compelling case for the systematic transformation of climate change education practice. When educators, institutions, and policymakers commit to harnessing the transformative potential of experiential pedagogies-grounded in local contexts, engaged with communities, informed by rigorous science, and explicitly oriented toward social justice, climate education can transcend its traditional role as academic subject matter to become a catalyst for personal and social transformation toward sustainability.

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