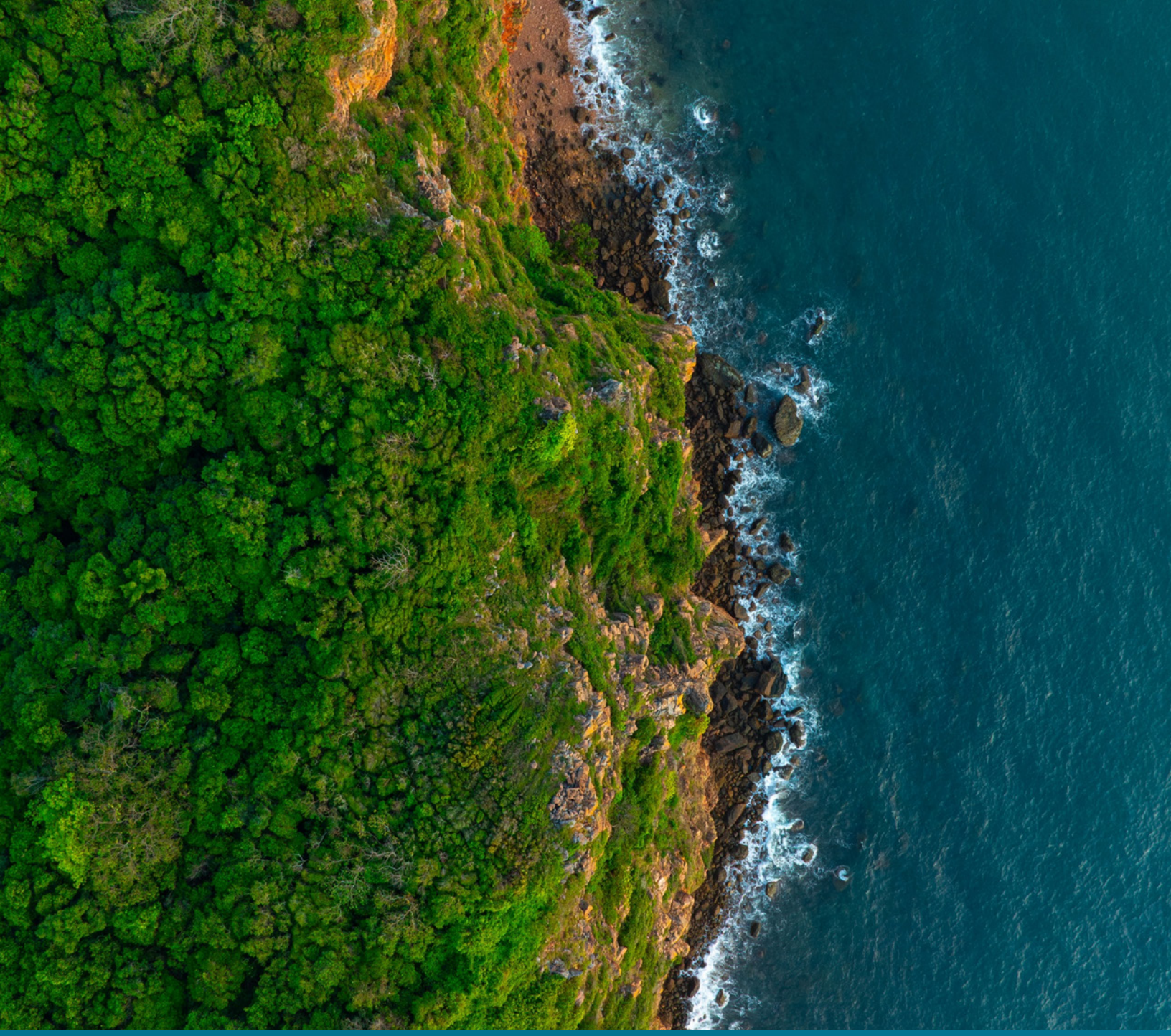

A Review of Research on Climate Education: From Science to Action

October 2025

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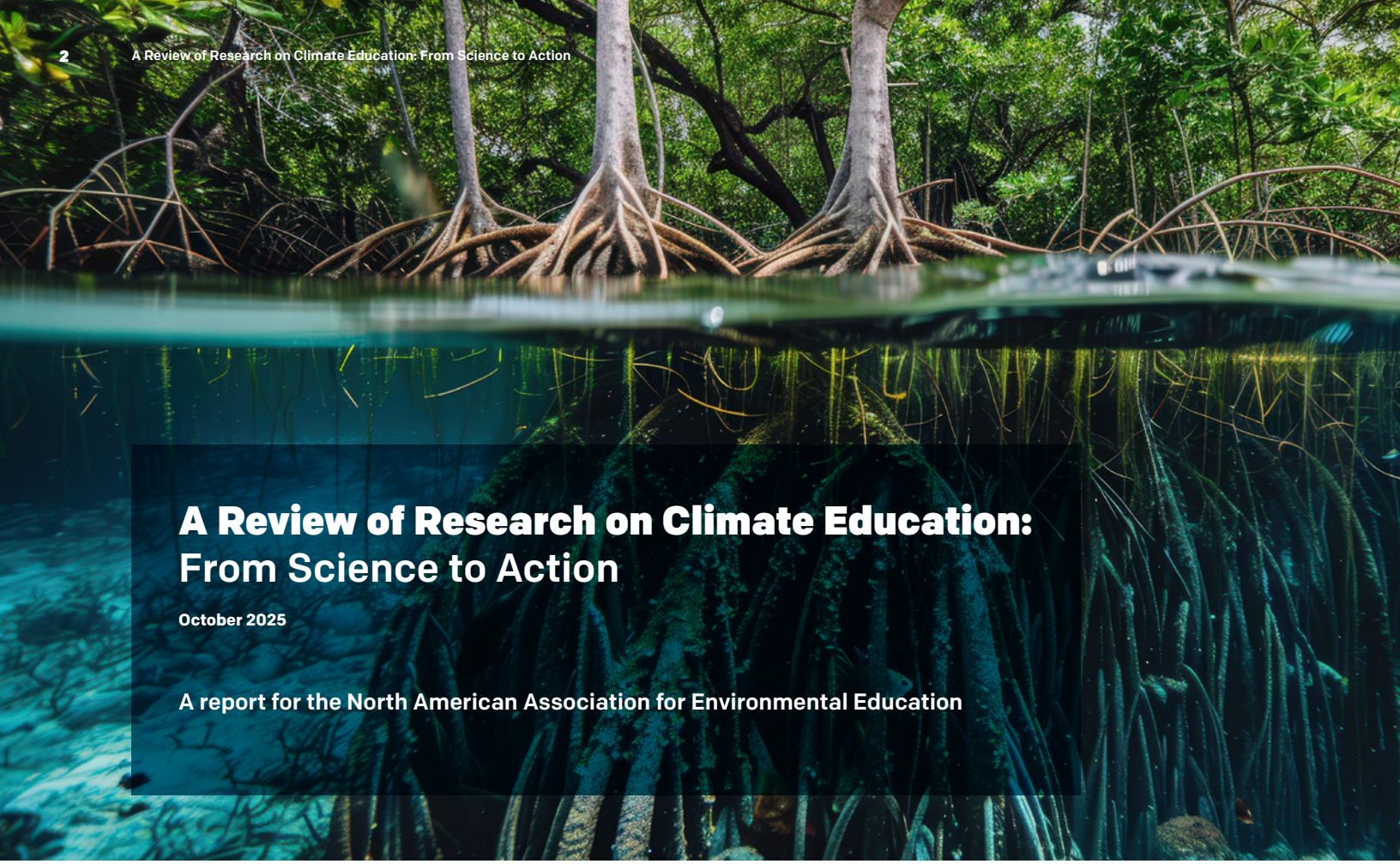

A Review of Research on Climate Education: From Science to Action

October 2025

A report for the North American Association for Environmental Education

Note

This report reviews the recent climate education research for discussion as NAAEE considers how to invest time and resources to enhance climate education in North America. It brings together a number of available reports and research, some of which describe programs and practices, but because many programs are not reported in the research literature, this compilation is not indicative of the climate education work that is being implemented across the continent. It is intended to be useful to NAAEE members and others who are developing programs, seeking funding, or evaluating climate education efforts.

To cite this report, please use: Monroe, M. C. (2025). A Review of Research on Climate Education: From Science to Action. Washington, DC: NAAEE

Acknowledgments

Immense thanks to Alison W. Bowers (Social Ecology Lab, Stanford University) for her keen thinking and myriad contributions to an initial version of this report. The following reviewers provided valuable feedback that strengthened this work:

- **Judy Braus** (NAAEE)
- **Natalie Cox** (International Union for Conservation of Nature)
- **Bill Finnegan** (University of Oxford)
- **Joe Heimlich** (Ohio State University)
- **Miloslav Kolenatý** (J.E. Purkyně University and Masaryk University, Czechia)
- **Lori Mann** (NAAEE)
- **Bora Simmons** (National Project for Excellence in Environmental Education)
- **Kathryn Stevenson** (North Carolina State University)
- **Jonathan Wickert** (Delaware Department of Education)

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Executive Summary

Climate change stands as one of the most pressing global challenges of our time, demanding unprecedented cooperation and action at all levels of society. This report explores the critical role of climate education in empowering individuals and communities to address climate change effectively. Our findings underscore the necessity of combining traditional climate education focused primarily on science with a more comprehensive approach that prioritizes action competence, along with a focus on other disciplines and approaches. Effective climate education must foster skills and motivation for mitigation and adaptation strategies, while developing knowledge of climate science, impacts, and solutions. It should build competencies in decision-making, critical thinking, and civic engagement; consider governance, economics, and culture; address emotional responses like climate anxiety and hope; and prioritize those most vulnerable to climate impacts and proposed actions.

This report reveals strong public support for climate education in the United States, with nearly three-quarters of Americans believing the government should encourage schools to offer climate education. However, despite this widespread support, the implementation of climate education in the United States remains inconsistent. To help address gaps in both formal and nonformal education, several frameworks for climate education have emerged, emphasizing interdisciplinary approaches, local relevance, and action-oriented learning. These models stress the importance of addressing cognitive, socio-emotional, and action-oriented dimensions of climate education in age-appropriate strategies.

Research demonstrates that well-designed climate education can lead to reductions in individual carbon emissions and increased climate-friendly behaviors, even years after completion. This underscores the potential long-term impact of investing in quality climate education. Importantly, many reports suggest that climate education should extend beyond formal schooling to include workforce development, community programs, and lifelong learning opportunities, creating a society-wide approach to support climate literacy and change. Critical to the success of these efforts is improved educator preparation and professional development.

This report highlights the need to integrate climate education across curricula, provide high-quality teaching materials, and support out-of-school, community-based, lifelong learning opportunities. By investing in comprehensive climate education that integrates climate science with strategies for mitigating and adapting to climatic changes, we can build a society capable of addressing the complex challenges posed by climate change. We hope this report will spark dialogue about how educators (both in and out of schools) can encourage climate understanding and engagement to empower learners of all ages to address these challenges and respond appropriately.

The Critical Role of Climate Education in the United States

The complexity and scale of climate change bring unique challenges that set it apart from other environmental issues (Moser, 2010). For example, a plan to address damage to the ozone layer was developed relatively quickly through industry phase-out of one chemical, chlorofluorocarbons (CFCs), and international cooperation such as the Montreal Protocol (Corfee-Morlot et al., 2007). In contrast, climate change is driven by greenhouse gases that cannot be eliminated so simply. They are byproducts of a diverse array of activities including energy production, transportation, and agriculture occurring at regional, community, and individual scales, making climate change solutions far more complex and economically disruptive (IPCC, 2023). Some environmental problems such as water and air pollution often have immediate, visible impacts and point-sources that lend themselves to local solutions, at least in part (Moser, 2010). In comparison, climate change operates invisibly on a global scale with long-term consequences that, while increasingly evident, can be more challenging to connect to their cause and source. Finally, the loss of species and the degradation of habitats such as forests and wetlands both drive and exacerbate the impacts of climate change, making attention to biodiversity a critical part of climate solutions (IUCN, 2022) and potentially a less controversial entry point for climate educators.

Addressing the complex causes of climate change requires fundamental restructuring of global energy systems and economies, unprecedented global cooperation, a continued commitment to sustainable lifestyle changes, a global prioritization of biodiversity, and a shared belief that a low-carbon future is desirable and achievable. Conventional educational models, including those focused solely on science knowledge or environmental awareness, are insufficient to foster the innovative thinking and skill-building essential for meaningful individual and collective change. Instead, ***we need climate education that also prepares learners to act.*** Action-focused climate education that engages and serves all learners, is rooted in science, and develops skills—including collaboration skills—is the glue that motivates and connects the web of solutions to create lasting change.

Climate education not only informs and empowers individuals but supports and amplifies the social norms for collective action that drive technological innovation, workforce development, and sustainable practices across sectors and communities to address climate change. While this is the vision for climate education, more research is needed to guide how educators achieve these goals (Abuya et al., 2024). In this report, we summarize recent literature and reports about climate education by presenting benefits of climate education, discussing the state of climate education in the United States, outlining approaches to climate education, offering examples of established and visionary programs, and synthesizing evidence in the research findings that climate education can be an effective force for change.

The Potential of Climate Education: Transforming People, Society, and the Environment

The primary goal of climate education is to equip people and communities with the knowledge, skills, and motivation to understand, mitigate, and adapt to climate change (UNESCO, n.d.). Ideally, climate education will lead to decreases in greenhouse gas emissions, addressing the detrimental effects of a changing atmosphere such as global warming, sea level rise, ocean acidification, more frequent and intense weather events, changes in precipitation, ecosystem disruption, and biodiversity loss, among others (IPCC, 2023). As more climate change impacts are experienced in communities all over the world, helping people adapt to climate change (including building resilience and addressing mental health concerns associated with climate anxiety) is becoming an increasingly important role of climate education (Abuya et al., 2024; Anderson, 2012; Olsen et al., 2024; USAID, 2023). Reflecting the bidirectional relationship between climate change and education (i.e., education can impact climate change, and climate-related disasters and increased heat can disrupt learning; Goodman et al., 2018), NGOs and governments are developing and investing in climate resilient education (USAID, 2023) and climate smart education (Global Partnership for Education, 2023; Save the Children & Global Partnership for Education, 2023). Climate education in each nation should evolve to address the emerging issues in their region, with a triple focus on knowledge development, a commitment to building individual and collective action skills, and an investment in resilience.

> *Climate change education helps people understand and address the impacts of the climate crisis, empowering them with the knowledge, skills, values, and attitudes needed to act as agents of change.*
>
> (From UNESCO, n.d.)

In preparing for this report, we discovered many reports on climate education from across the globe that can help nations determine how to best address the changing climate in their region. See Appendix A for a list of key reports and their area(s) of focus.

While mitigating and adapting to climate change are the ultimate goals of climate education, learning about climate science, understanding governance, gaining skills in critical thinking and problem solving, and having opportunities to become engaged in action projects can lead to wide-ranging environmental, economic, societal, cultural, political, health, and educational benefits (see Box 1).

However, demonstrating that educational interventions produce lasting behavioral change and linking this change to climate impacts is challenging due to the dynamic interplay of factors that influence behavior and the extended timeframe over which effects emerge (Ardoin et al., 2020; Cordero et al., 2020). Researchers and evaluators face difficulties isolating the specific impact of education from other societal influences (McLusky and Sessa, 2015) and in developing assessments that capture the range of potential outcomes (Howard-Jones et al., 2023). Methodological challenges such as self-reporting biases, establishing control groups in educational settings, lack of funding for evaluation, and the evolving nature of the public discourse around climate change further complicate efforts to quantify the effectiveness of climate education. Some programs have been evaluated with pre- and post-assessments, which provide insights into what the educational program can accomplish in the short term. Very few have been evaluated for change over time.

Box 1. Potential Outcomes That Could Be Achieved from Effective Climate Education Programs

Short Term Outcomes

- Climate, biodiversity, and scientific literacy
- Systems thinking skills
- Critical thinking skills and the ability to identify and combat misinformation
- Communication, leadership, and teamwork skills
- Vocational training in green/blue skills
- Ability to acknowledge and address climate emotions

Mid Term Outcomes

- Environmental awareness and concern; willingness to take pro-environmental action
- Identification of disinformation; engagement with reputable scientific sources
- Group and collective efficacy in addressing climate issues
- Qualified workers for green/blue jobs
- Connection to nature and emotional resilience

Long Term Outcomes

- Widespread adoption of low-carbon behaviors; shift toward sustainable lifestyles; support for conservation policies and actions
- Increased public trust in science and scientific institutions
- Civic engagement leading to new climate policies
- Less dependence on social welfare systems
- More resilient, sustainable economy/workforce
- Improved public health outcomes, such as enhanced well-being

A Snapshot of the Current State of Climate Education in the United States

Most of the research on climate education in the United States has addressed formal education, with a focus on secondary education, then higher education, and much less on nonformal education. As a result, most of the reports and reviews also prioritize school-based learning. Because this report is based largely on the research literature, it maintains this focus on formal education for school-aged children (in schools and in community programs for youth that supplement classroom education) and young adults. We also include findings from several adult nonformal programs. The student emphasis is warranted, however, as these age groups represent critical periods for shaping students' understanding of complex global issues such as climate change. In preK–12 education, teachers can help lay the foundation for lifelong climate literacy and civic engagement, while higher education can provide more specialized preparation for careers as well as climate science and its implications. Ideally, however, climate education will extend beyond formal education settings to include out-of-school environments and community-based efforts to increase public engagement for learners of all ages.

Widespread Support for Climate Education

Despite extensive media coverage of climate change deniers, recent survey data indicates that most Americans believe human-caused climate change is happening. The annual Global Warming's Six America's survey from Yale and George Mason Universities has tracked a large increase in people described as "alarmed" about climate change and a matching decrease in those categorized as "cautious" over the last 15 years, resulting in 57% of the American public being alarmed or concerned about climate change and a steady minority of 22% being doubtful or dismissive (Leiserowitz et al., 2024). Their regular updates are worth exploring to see trends and changes **(Global Warming's Six Americas, Yale Program on Climate Change Communication).** This belief and concern have translated into large swaths of support for formal climate education. A full 74% of Americans believe the government should encourage schools to offer climate education, with over half (59%) of Republicans agreeing (Lange, 2023). This is consistent with an earlier poll that found 77% of American adults believe it is important that elementary and secondary students learn about climate change (Pizmony-Levy and Pallas, 2019).

Not only does the public favor climate education, 74% of K–12 teachers and 70% of school administrators recently surveyed also believe it is their responsibility to teach students about the changing climate (Edge Research and NAAEE, 2022). Most teachers (67 to 80%) prefer to see climate education integrated across subject areas (with variation along grade levels), but currently it is offered primarily in middle school and high school earth or environmental science classes (Beaver et al., 2024; French et al., 2025; Edge Research and NAAEE, 2022). At the same time, however, administrators worry about parents complaining if climate change is covered in the classroom. They would like to see community partners offering opportunities for students to engage in climate projects (Edge Research and NAAEE, 2022).

A national survey conducted in spring 2023 of over 1,000 American adults found that most Americans are unaware of climate justice. After the term was explained, about half of the respondents supported climate justice goals (Carman et al., 2025). Very few respondents initially recognized that addressing disproportionate vulnerabilities from climate change was a fundamental principle of climate justice.

According to a recent search, over 1,000 organizations and institutions provide climate change education and communication in the United States that operate in the nonformal sectors (Centre for Sustainable Futures et al., 2024). An estimated half of these organizations are focused on climate change and support their local school districts, reaching teachers and students, as well as the public. In addition, many museums, zoos, parks, informal science centers, and nature centers have exhibits and programs that address climate change. For some, climate is embedded in existing programs on wildlife or weather. Others offer programs focused on climate, such as The Wild Center's Youth Climate Summits and Climate Solutions exhibit **(https://www.wildcenter.org/our-work/climate-science)**.

Not Widespread Implementation

The national data, however, hide discontent with policies and practices that are commonly discussed as strategies to slow emissions of atmospheric carbon. In many communities, teachers perceive barriers to teaching about climate change from administrators, parents, other teachers, and students (Worth, 2021). Teachers are concerned that their administrators won't support them, and administrators are worried about parents complaining (Edge Research & NAAEE, 2022). Some community opinions are linked to disinformation that claims climate change is a hoax. As political winds shift over time, these voices become stronger, affecting state standards and social norms in some communities (Waldman & E&E News, 2023). Many teachers avoid teaching about any controversial issue, citing a lack of current knowledge about the topic, but more importantly, a lack of training in how to encourage critical thinking to evaluate different viewpoints and ensure all students feel respected and valued (Clabough et al., 2011; Karousiou et al., 2025). Even though they believe students deserve to discuss current issues, some teachers do not believe they have administrative support to do so (Waddington et al., 2025). Unfortunately, some state standards, which are also shaped by political currents, encourage teachers to convey that climate change could be caused by natural changes and to explore all perspectives (MECCE & NAAEE, 2022).

Educators still have options, however. Some teachers find that focusing on personal, community, and ecological resilience in the face of deadly storms and floods is an acceptable way to prepare students for a challenging future. In some cases, teachers ask climate educators from outside the school system to provide guest lectures. Other teachers suggest that attention to the cultural norms that create dissonance when discussing climate change could help identify ways to communicate (Long et al., 2022). The Climate Denial Inquiry Model (Damico et al., 2023) is a pedagogical tool to guide learners to questioning, exploring, and discussing climate reports, thereby building their media literacy skills.

In 2019, researchers repeated a 2014 survey of middle and high school science teachers in the United States. In addition to reporting that more teachers are covering climate change, using the scientific consensus, and spending more time addressing it, the authors looked at the geographical distribution of respondents and the personal beliefs of those who are and aren't teaching about climate change (Plutzer et al., 2024). A large minority of teachers (44%) emphasize the false claim that many scientists believe global temperature increases are due to natural causes. These teachers are more likely to teach that anthropogenic climate change is controversial and give equal time to all perspectives. They are more likely to (a) reside in one of the 30 states that has not adopted the original Next Generation Science Standards, (b) encourage debate about the causes of climate change, and (c) be less knowledgeable about climate science (Plutzer & Hannah, 2018). Unfortunately, teachers are prone to the same misconceptions about climate as their students (Foss & Ko, 2019; Plutzer et al., 2016). As useful as debate can be as a teaching strategy to increase knowledge and communication skills, when students are asked to debate something, teachers give the impression that the topic is not a fact; students are likely to assume the issue is undecided. This practice also undermines students' abilities to meaningfully address mitigating actions (Beaver et al., 2024). Plutzer et al. (2024) conclude that, much like the general public, teachers' personal beliefs about climate science have the greatest impact on their teaching behavior. These results were confirmed in a study that used Plutzer et al.'s survey with secondary science teachers in California and Texas. The California teachers have a better understanding of the greenhouse effect and emphasize the scientific consensus more often than their Texas counterparts, but some still hold misconceptions. Over 70% of the Texan respondents use debate as a teaching strategy to cover climate change in the classroom (Khalidi & Ramsey, 2021).

At the time of this analysis every state had at least one educational policy that mentions climate, although there is great variation in how climate change is addressed across the United States. In an analysis of 802 educational policies from state educational agencies, only Indiana, California, Maryland, and the District of Columbia were deemed to have a "moderate" level of climate change policy; 33 states were coded "very low" (MECCE & NAAEE, 2022), though this study does not report policies that are in the process of being revised. In 37 states, climate change is taught only in the cognitive domain (knowledge), and only four states cover all three domains: cognitive, action-oriented, and socio-emotional. Teaching about climate was most often tied to the science curriculum. Additionally, a review of the U.S. K–12 science standards found that most climate standards are in the high school earth science domain and are presented in classes that most students do not take (Beaver et al., 2024; French et al., 2025). Furthermore, while earth science can offer a robust understanding of atmospheric change, it provides a limited awareness of climate change impacts, missing those associated with human health and biotic systems, for example. Some states cover climate change generally, for example, as one of several disruptors of ecosystems or as a multidisciplinary issue, such as nanotechnology and agriculture. Other states prevent the use of the words "climate change." For example, the Florida Department of Education is restricting mention of climate change in science textbooks that are accepted for use in schools (Postal, 2024).

Teachers have some degree of flexibility in how they teach about climate change. In an exploration of science teachers in the state of Delaware, however, teachers' personal political orientation often shapes how teachers cover the topic of climate change, independent of the state standards (Henderson et al., 2024). Even secondary science teachers question the scientific consensus on climate change (Kunkle & Monroe, 2018).

In addition, teachers' personal sense of worry about climate influences whether they include climate change in their classroom lessons. A recent online survey of 353 educators suggests their emotions make them hesitant but also inspire them to talk to students about climate change (Clayton et al., 2023). Those from states that include climate in the curriculum and those who taught about climate tended to express less anxiety. These findings highlight the importance of supportive policies and resources in helping educators address climate change.

The literature discussed above assesses the state of public school climate education, which misses the nonformal community as well as learners younger than 5 and older than 18 years. Of course, investing in public education may be the first and most logical way to advance climate education, but it is not the only possibility. Among early childhood educators, one survey found educators with nature-based programs prefer to use natural settings and encourage behaviors such as recycling to cultivate responsible action and care for the environment, though this can vary by community (Ginsburg & Audley, 2020). For example, Finnish early childhood educators suggest their role should be to provide a safe learning environment and model ways that reflect their environmental values (Hilander et al., 2023). Among adult educators, climate change has been discussed in the context of how to teach about sustainability issues (Griswold, 2024), but is not yet widely practiced. Some adult programs address climate directly, such as the UC Climate Stewards course (Nelson et al., 2022). On the other hand, an examination of 74 general climate change course syllabi offered at higher education institutions reveals most are focused on climate science; climate change solutions and communication are mentioned much less often (Cooper et al., 2019).

Frameworks and Models of Climate Education

Several frameworks have been proposed to guide the development and structure of climate education. In this section, we present a few models to illustrate the commonly addressed key principles and approaches. While some nations have adapted their original environmental education or education for sustainability curricula to serve climate education, others have created new goals and objectives for climate-specific education. These frameworks reflect the evolving understanding of climate change not just as an environmental science issue, but a complex, multifaceted concern that braids together science, social, economic, and political systems. Over time, the vision for climate education has shifted from the purview of earth science to other subjects, such as geography, sustainability, environmental science, and social studies, though in practice and in national curriculum the emphasis is more likely to be on the causes of climate change rather than strategies for mitigating, adapting, and taking action (Dawson et al., 2022). In this sense, climate education may be similar to environmental education, which since the 1970s has included ethics, decision-making, and technology, alongside natural resource management and ecosystem science (Stapp & Cox, 1974), though not in common practice at the time. Even today, while people may understand the importance of addressing environmental education and climate issues across disciplines, it may not be easy to do in schools (Kissling & Bell, 2020).

U.S. Global Change Research Program

In the United States, the U.S. Global Change Research Program and its member federal agencies released a revised resource for educators, communicators, and policymakers, *Climate Literacy: The Essential Principles of Climate Science* (USGCRP, 2024). The guide identifies eight climate literacy principles, emphasizing the human causes of climate change, its widespread impacts on ecological and human systems, the importance of equity and justice in climate action, and the need for urgent action at all levels of society to address climate change. The eight principles are (USGCRP, 2024):

1. Scientists understand the climate system through interdisciplinary observations and modeling.
2. Greenhouse gases shape Earth's climate.
3. Burning fossil fuels and other human activities are causing the planet to warm.
4. Rapid warming and other large-scale climate changes threaten human and ecological systems.
5. Climate justice is possible if climate actions are equitable.
6. Humans can adapt social, built, and natural environments to better withstand the impacts of climate change.
7. Reducing emissions of greenhouse gases from human activities to net zero by 2050 can help limit global warming and climate change impacts.
8. A livable and sustainable future for all is possible with rapid, just, and transformational climate action.

Monitoring and Evaluating Climate Communication and Education (MECCE) Project

The Monitoring and Evaluating Climate Communication and Education (MECCE) Project, an international partnership of over 100 scholars and organizations, co-authored a report with NAAEE examining the current landscape of U.S. K–12 climate education policy. They mapped climate change content as presented in publicly available state-level education documents across three dimensions that they outlined as ideal climate education when offered together: cognitive, action, and socio-emotional (see Box 2). The report authors argue climate education should include all three dimensions but reported that while all states included cognitive climate content, only 20% had socio-emotional content and 16% included action-oriented content.

Box 2. Three Categories of Holistic Learning Dimensions Define What Could Be Included in Climate Change Education

- ***Cognitive:*** Aimed at developing the knowledge of and the learning agility necessary to better understand climate change, including its underlying anthropogenic and biophysical causes, impacts and solutions.
- ***Action-oriented:*** Aimed at developing action competencies, including skills and practices, individual and collective agency, and behaviorial change to address climate change and to minimize one's own collective climate impact.
- ***Socio-emotional:*** Aimed at developing emotional intelligence and/or interpersonal skills that enable learners to process emotions and feelings about climate change and its impacts, and to more effectively collaborate, negotiate, and communicate with others to address climate change. This can incude self-reflection skills, knowledge, values, attitudes, and motivations that enable learners to build their own capacity for resilience and action.

(From MECCE & NAAEE, 2022, page 7)

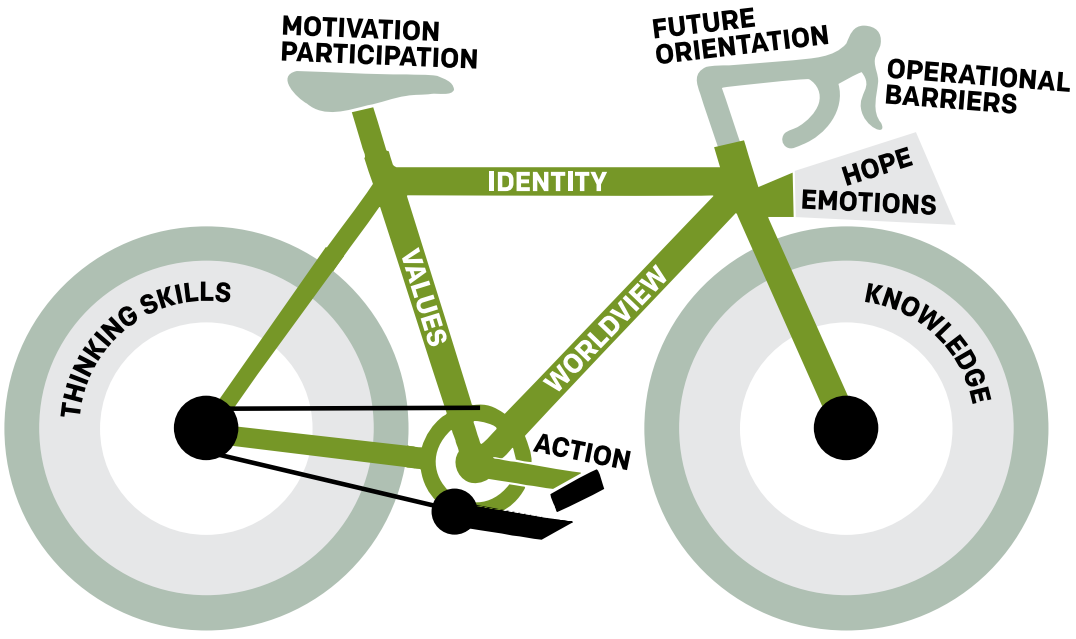
Bicycle Model

In Europe, the popular "bicycle model" of climate change has gained traction and been used to frame a variety of programs and curriculum (see Box 3). Developed by a team from Finland, each part of the bicycle represents an essential aspect of climate education (Cantell et al., 2019):

- Two wheels are essential for moving forward and define a bicycle. They represent knowledge (including knowledge of natural causes, changes in the climate system, and impacts to the environment and humans) and critical thinking skills to evaluate information, assess values, and reflect on alternative future scenarios through systems learning.
- The frame provides the foundation for this knowledge through identity, values, and worldview.
- The chain and pedals transfer the knowledge to action to curb climate change. This requires effort and should be applied to real issues that are relevant to the learner.
- The bicycle seat represents the cyclist's motivation and participation, which are essential for the learner to apply their knowledge and skills and to work together to be successful.
  - Brakes help clarify the operational barriers to action, such as denial, social norms, the desire for comfort, passiveness, or existing habits, as well as structural barriers such as the lack of infrastructure or funding.
  - The headlight represents hope and other emotions, which show the way forward.
  - The handlebar steers the bicycle by emphasizing a future orientation, both critical and positive.

The model has been useful in guiding teaching, teacher education, learning, and program development and showing the importance of connecting all seven elements for effectively addressing climate education.

Box 3. The Bicycle Model on Climate Change Education



A bicycle provides a handy tool to remember important elements of climate education.
(From Cantrell et al., 2017, page 719; Tolppanen et al., 2017, page 459)

Transformative Education

In some conversations, transformative societal change, which involves fundamental changes in social, economic, and technological systems, is heralded as critical to addressing current environmental challenges (IPCC, 2023; Steffen et al., 2018). Some U.S. educators call for a radical transformation of our education system to address inequalities in academic achievement and workforce preparedness, high levels of student disengagement, and learning loss due to school closings and hybrid learning during the COVID-19 pandemic (Challenge Success, 2024; Education Reimagined, 2020). This convergence of both environmental and educational spheres has led several scholars to combine climate education and transformative learning theory (e.g., Leite, 2024; Littrell et al., 2022; Ruiz-Mallén et al., 2022; Trott, 2021). Emerging from the field of adult education, transformative learning theory emphasizes a disruptive experience where critical self-reflection and rational discourse change problematic frames of reference, empowering learners to take action that is grounded in new perspectives (Mezirow, 2009).

Building on these conversations about the nature and potential of education, Kwauk and colleagues (Kwauk, Paez et al., 2023; Kwauk, Siba et al., 2023; Kwauk & Casey, 2021, 2022) propose an expansive vision of transformative climate education that addresses systemic inequalities and drives societal-level change. The "New Green Learning Agenda" emphasizes skills for green jobs, green life skills, and skills for a green transformation. This framework also expands the transformative potential of climate education beyond individual learners to encompass institutional and societal transformation. Kwauk and colleagues argue that climate education should not only prepare individuals for green jobs but should also equip learners with the capacities to challenge and change unsustainable systems, address historical injustices, and lead community-driven solutions. This approach positions climate education as a catalyst for broader social and economic transformation toward a more just and sustainable future.

Head, Heart, Hands Model

The Head, Heart, Hands model, as presented in Sipos et al. (2008), integrates cognitive engagement, critical thinking, and learning (head); psychomotor development through practical skills (hands); and affective growth involving values and attitudes (heart) to foster changes in learners' knowledge, skills, and attitudes related to sustainability. While they use the term transformative and apply aspects of transformative education, Sipos et al. do not call their action experiences disruptive. Developed for use in sustainability learning in higher education, the model has been used in climate education programs to achieve changes in program participants (Brandes, 2024; Trott, 2021). In their systematic review, Olsen et al. (2024) highlight the value of such holistic models that integrate knowledge, action, and emotions to address eco/climate anxiety that can arise in learners grappling with climate change.

NAAEE Guidelines for Excellence

In 2024, NAAEE published a new document in the NAAEE Guidelines for Excellence series: Educating for Climate Action and Justice (https://www.climateliteracy.earth/resources). Experts from across the United States followed the iterative Guidelines process to develop key characteristics, guidelines, and indicators for aspirational climate education that addresses both climate action and climate justice (NAAEE, 2024). The guidelines advance previous work in climate education by integrating climate justice and climate action with climate science—giving learners opportunities to understand and work with vulnerable populations and communities that are disproportionately impacted by environmental threats and to encourage community actions that support equitable climate adaptation and mitigation strategies. Justice is incorporated throughout each section. The following characteristics build a foundation of both cognitive and affective elements, while engaging learners in local action projects to build hope and efficacy (see Box 4).

Box 4. Key Characteristics of Climate Education

- ***Collaborative, Welcoming, and Responsive*** Learning Environments provides guidance to educators to create an atmosphere that will foster effective learning for all students and enable them to explore alternate worldviews and misconceptions.
- ***Knowledge and Skills to Foster Climate Action*** builds awareness in younger learners, and builds knowledge and skills in older learners to understand climate science, natural and human systems, and the types of individual and collective actions that lead to climate justice and solutions.
- ***Attention on Climate Emotions*** reminds educators that climate change is laden with hope, fear, anger, anxiety, and concern. This section offers background information and strategies for addressing these emotions.
- ***Locally Focused and Community Driven*** speaks to the importance of place-based education where learners apply climate perspectives in their community, and also the importance of working with local partners to create change at the neighborhood or community scale. Engaging community organizations and leaders helps ensure that solutions will be more relevant, equitable, and effective for all residents.
- ***Civic Engagement for Climate Action*** emphasizes the power of collective action at the community level and empowers learners to use their knowledge and skills to work with others to address a climate challenge they choose.

(From NAAEE, 2024)

Organisation for Economic Co-Operation and Development's Science Framework for the Programme for International Student Assessment

A group of international science and environmental educators have responded to the Organisation for Economic Co-Operation and Development's (OECD) request to link the Science Framework that underpins their Programme for International Student Assessment (PISA) to environmental action competencies (Monroe et al., 2023). OECD research suggested that youth around the world were aware of environmental issues, particularly climate change, and were concerned, but they didn't know how to address these problems (OECD, 2022). Researchers developed a supplement to the Science Framework, Agency in the Anthropocene (White et al., 2023), that calls for nations to adjust their curriculum to prepare youth to "work individually and collectively with hope and efficacy to understand diverse perspectives on socio-ecological systems and act to create a more just and resilient future" (White et al., 2024, e119). The document also introduces and justifies three additional competencies to empower young people to address socio-ecological issues:

- Explain the impact of human interactions with Earth's systems
- Make informed decisions to act based on evaluation of diverse sources of evidence and application of creative and systems thinking to regenerate and sustain the environment
- Demonstrate hope and respect for diverse perspectives in seeking solutions to socio-ecological crises (White et al., 2023, p. 16)

The revised science competencies include media literacy and the competence to evaluate the credibility of scientific information (Osborne & Pimentel, 2022). OECD has recently embarked on a process to add climate literacy to other subject domains, not just science, and support educators with both resources and practice assessment items. Their recent report on climate and education establishes three critical strategies: cross-curricular learning, place-based approaches to address collective climate action, and policies that increase education system resilience (Nusche et al., 2024).

Box 5. Explaining Climate Change Behavior Among Young People

Several factors are potential determinants of pro-environmental behavior that addresses climate change. Research studies tend to isolate a single variable to explore the degree to which it is responsible for increased willingness to act. From these, we believe that educational programs increase knowledge, concern, or problem-solving skills (Monroe, et al. 2019). In this study, researchers linked several factors together and tested a model that links education to behavior (Stevenson, et al., 2018).

The team revised several Project WILD activities to create four lessons for middle school teachers to use in their classes. The focus on wildlife helped reduce the concern that climate change can generate among administrators, teachers, and parents. The activities covered these topics:

- The difference between weather and climate
- How weather and climate relate to habitat and wildlife
- How wildlife managers are planning for climate change
- How individual actions can mitigate climate change and improve climate resilience among wildlife

Eighty-five middle schools were selected from the list of all public schools in North Carolina; 205 teachers from these schools were invited to participate in the study, of which 24 completed the program. The final sample of their students included 1,041 sixth, seventh, and eighth graders assigned to control and treatment groups by class. Most students (64%) came from Title 1 schools, an indicator of lower-income families. Teachers attended a one-day, in-person training to become familiar with the study protocols and the activities and then shared ideas with each other online. The student survey instrument measured climate change knowledge, hope, concern, and behavior; it was implemented after the training and again after the lessons, at the end of the school year (3 to 6 months later).

Taking into account the pre-test scores and Title 1 status, a structural equation model analysis suggests that the educational program increased climate change knowledge. The increased knowledge changed concern more strongly, but also changed hope, both of which predicted change in climate mitigation behaviors (hope more strongly than concern). Title 1 status diminished knowledge, concern, and behavior measures.

(From Stevenson et al., 2018)

Key Syntheses of Climate Education Practices

A recent review of the literature and the needs for climate education prompted a team from Utah to define five elements of climate education that empowers learners to act (Janney et al., 2024). For them, the ability to take action is defined as adopting pro-environmental actions at the individual and collective levels. Their list of elements emphasizes the knowledge component, adds media literacy, and moves toward action:

- Functional knowledge of climate change science and systems
- Knowledge that climate change is human induced
- Knowledge that climate change has far-reaching consequences
- Ability to critically assess climate change claims and media
- Ability to take meaningful actions against climate change

Tang (2022) conducted a systematic review of 79 papers addressing climate change education in higher education and proposes a model to bridge the attitude-behavior gap. The model emphasizes three domains: (1) knowledge of climate science, political and economic facets of climate change, and climate injustice; (2) practical aspects to make climate change relevant to personal lifestyle and consumption choices; and (3) community aspects to engage students in action projects to foster teamwork, communication skills, leadership, and project management. The addition of justice is noteworthy, and the division of action into individual choice and community projects is useful as they may require different skills and background.

A systematic review identified several themes that were evident in formal and nonformal education for youth and adults (Monroe et al., 2019):

- Relevant examples and a place-based context makes information personally meaningful, which is helpful for learning and memory.
- Engaging, interactive teaching methods help learners use all their senses and focus attention.
- Interacting with local scientists, collecting their own data, and analyzing databases convey the nature of science and give people their own evidence of climate change.
- Encouraging deliberative discussions, explaining evidence, and addressing misconceptions are additional strategies to build skills that engage learners in community conversations.
- Opportunities to implement projects at school or in communities build efficacy, team skills, and hope—all essential for preparing learners to address the current climate challenge.

Another review cast a slightly larger net, searching the literature for empirical studies about teaching and learning about climate across formal K–16 systems (Bhattacharya et al., 2021). They summarized 178 papers and found that climate change is covered primarily in secondary science courses in relatively short units (one week), but not in all schools. Teachers feel unprepared to teach about climate change and believe professional development would be valuable. Simplistic models and misconceptions about global warming and climate change are common among students and teachers. Due in part to the power of culture and emotion, they recommend that climate change be taught through place-based, local issues that are relevant to students, and that more instructional resources be developed that are comprehensive, adaptable, and based on climate science.

An older literature review coordinated by the Brookings Institution sought to identify recommendations for climate change education based on "evidence-based research that assesses what factors influence skills, attitudes, and behavior change the most" (Anderson, 2012, p. 196). Their conclusions repeat what we know to be true about environmental education:

- Effective climate education should include active learning activities throughout a cross-discipline curricula.
- Active learning should be connected to place-based problem solving.
- Climate education provides scientific knowledge as well as problem solving and critical thinking skills.
- Working with individual carbon footprints represent one way to explore direct action for climate mitigation.
- Teacher education is essential.

Putting the Visions Together

These frameworks, models, and guidelines share many common elements. They all speak to the need for climate education to encompass what people need to know to take appropriate actions to mitigate and adapt to climate change. They recognize this will involve climate science education, initially embedded in the earth science curriculum, and education that includes impacts and solutions, creates agency, and empowers learners to bring about individual and collective change in their households and communities. A North American perspective suggests that climate education should include:

- Knowledge of climate science, biodiversity, and of the factors (ecological, economic, political, and cultural) affecting the causes of climate change, making climate education interdisciplinary. This broad foundation is needed to weigh the advantages and disadvantages of proposed solutions and action strategies.
- Knowledge of mitigation and adaptation strategies that can be and are being implemented elsewhere and locally, by nations, communities, families, and individuals, while acknowledging different levels of resources and abilities within a population. This should help nurture hope and efficacy while addressing equity and justice.
- The knowledge and skills to implement selected strategies, either by individual decisions to change behavior or by collective efforts to encourage social change in business and industries, organizations, and governments, such as building partnerships, understanding special interests, organizing meetings, and presenting compelling requests for equitable changes that promote justice.
- Skills in decision-making, identifying misconceptions and misinformation, communicating, collaborating effectively in groups, critical and systems thinking, persuading, and leading groups.
- Skills for supporting and working in new businesses and industries associated with protecting and sustaining the environment that are arising in the transition to a low-carbon future, as well as knowledge and skills to help existing businesses and industries adapt to and cope with change.
- Acknowledgment of potential fears, uncertainty, and anxiety while building constructive hope and cultivating concern that will motivate and sustain action.
- Opportunities to participate in selecting, planning, implementing, and celebrating climate action projects to build skills and efficacy—both individual and collective

This list blends cognitive, socio-emotional, and action-oriented elements into one science-based but interdisciplinary approach to climate education. It includes environmental justice, media literacy, and green jobs. It can be a vision for K–12 education that builds a strong foundation in elementary years, culminating in community projects with older students. Many of these goals can also be addressed through nonformal education programs for young people and adults. These goals can also guide the development of university offerings and adult programs.

Building Both Climate Science and Climate Action

Data suggest knowledge about climate change is the foundation for concern and willingness to act (Kolenatý et al., 2022; Stevenson et al., 2018), which reinforces the importance of teaching climate science. This information need not be limited to the science curriculum, however. Both CATE (Climate Action Through Education) and Subject to Climate (https://subjecttoclimate.org) offer educators a variety of instructional resources to embed climate concepts in language arts, math, and social studies courses. And, too, there are different ways of knowing as well as different types of knowledge. It may be particularly valuable to engage with those who have a deep cultural connection to the local landscape. While climate science was initially stressed in earth science classes, knowledge also includes impacts of climate change on natural and human systems, strategies for mitigating change, effectiveness of different mitigating activities, and the suite of solutions communities are implementing to adapt to change (Bofferding & Kloser, 2015), as well as Indigenous Knowledge and cultural frameworks.

Procedural knowledge is also essential (Schultz, 2002), as well as how vulnerable communities are disproportionally challenged by both climate impacts and the suggested strategies to reduce these impacts. Teaching the skills that change agents need, such as analyzing situations and weighing alternatives (essential elements of environmental education), are also making their way into climate education (Hines et al., 1986/87).

There is broad agreement that providing people with a stronger background in the causes of a warming planet or atmospheric science, although important, is not enough to prepare them to take individual and collective action to address mitigating and adaptive solutions (Busch et al., 2019; Cantell et al., 2019; Howard-Jones et al., 2021, Kagawa & Selby, 2010; Monroe et al., 2019; Otto et al., 2020; Rousell & Cutter-Mackenzie-Knowles, 2020; Tang, 2022; Morrissey Gleeson & Morrissey, 2024; Trott, 2024; Wodika & Middleton, 2020). Delegates at the United Nations Framework Convention on Climate Change (UNFCCC) meeting in Paris even renamed climate change education to "Action for Climate Empowerment" and aligned this work more closely with the Sustainable Development Goal 13: Climate Action.

In addition, there is a growing realization that those in power may be more incentivized to delay action or redirect attention rather than promote changes that mitigate greenhouse gas emissions (Lachapelle et al., 2024; Oreskes & Conway, 2011). Greta Thunberg's steely resolve empowered over a million youth around the globe to support change through School Strikes for Climate in 2019 (Bright & Eames, 2022; Verlie & Flynn, 2022), many of whom demanded change of policymakers. The speed at which the climate has changed and the projections of how quickly impacts could be felt have mobilized youth to demand action from their leaders. Teachers who see a potential problem wading into these conflicted waters use their concern to justify not teaching about anthropogenic climate change (Clabough et al., 2011; Karousiou et al., 2025; Khalidi & Ramsey, 2021; Plutzer et al., 2024; Plutzer & Hannah, 2018; Waddington et al., 2025). The appropriate role for environmental education, however, is to inform and prepare learners to take responsible action, as it always has been (UNESCO, 1978). Preparing learners to act involves building action competence, which may not entail taking action.

There are several rock-solid reasons for climate education to include action competence. One is practical: People learn what they are taught. A unit on nature appreciation doesn't prepare students to recycle. Understanding albedo helps people make sense of warmer melting polar caps, but not how to share climate information with others. If we want to prepare people to act, we have to teach them what they need to know about potential actions, motivate their concern, and build the skills they need to make responsible decisions about whether to act. In this regard, a unit on nature appreciation could help motivate concern for nature, which is often seen as a precursor to environmental identity and pro-environmental behaviors (Clayton, 2003; Whitburn et al., 2020). How climate science is conveyed can also distance learners from the problem and decrease their concern. After a traditional science unit on climate change, secondary students were asked to explain their initial thoughts when thinking about climate change. The majority described the problem as human-caused and affecting physical Earth systems, on a global scale and in the future. This psychological distance correlated with climate concern, with those who felt distant from the problem being significantly less concerned than students who described climate change as a local problem (Busch & Chávez, 2022). The authors conclude that educational efforts should include local and concrete examples of climate impacts with relevance to students' lives. This should make it easier, though not automatic, for their knowledge to be channeled into concern and local action projects.

A second reason to expand climate education beyond climate science addresses the fear and anxiety young people express as they learn more about climate change; sea level rise; declining biodiversity; and regularly repeating cycles of flood, mudslides, drought, and wildfire (Hickman et al., 2021). Hope is an important element of being willing to take action. It can be nurtured through activities to learn how others are bringing about change (Ojala, 2023; Stevenson et al., 2018) and the process of working on projects in their own communities (Trott, 2021). Working together on a climate action project can also build constructive hope (Ojala, 2023). Students seem capable of having both concern and hope, and of using them to promote action.

A survey of 512 secondary students in England revealed that students believe a negative future is more likely than a positive one but also exhibit a strong positive correlation between hope and action competence (Finnegan, 2023a). A survey of over 400 high school students from the state of Washington reveals that a suite of emotions (including worry, concern, and empowerment) had an enormous impact on students' willingness to act (Hundemer et al., 2026). In addition, both hope and anxiety, for example, are mentioned as triggering engagement in pro-environmental school activities and protests (Bright & Eames, 2022; Finnegan, 2023a; Trott, 2019).

Box 6. Czech Youth Learn and Become Engaged in a Nonformal Program

The CO2 League is a popular after-school program for middle and high school students in the Czech Republic. It was developed by a Czech environmental organization, the Ecological Institute Veronica, and funded by their Ministry of Environment. Youth volunteer to participate and work in teams of three to six students and one teacher tutor based at their school. The program runs over one school year and involves four missions. The first builds knowledge of and concern for climate change through videos, readings, and art. Students share what they have learned with classmates through presentations, posters, and videos. In the second mission, the teams learn about ways to mitigate climate change through personal actions with the carbon footprint and explores ways they can reduce their own emissions. Youth build self-efficacy and action skills in the third mission by exploring local areas that are susceptible to floods and droughts and then meet with local stakeholders and present proposals to community leaders in the fourth mission.

The research team met with program authors and education experts to identify appropriate outcomes for the program, focusing on climate literacy and willingness to engage in climate action. A pre/post survey was developed with 45 items covering climate science, mitigation activities, climate beliefs, self-efficacy, and willingness to act. A total of 21 (out of 47) teams completed the program, generating 123 matched surveys. Six student focus groups (n=27) and six interviews with teachers were also conducted to explore the program experience.

Participating in the program significantly increased survey scores for all variables, with knowledge scores improving more than climate concern, self-efficacy, or willingness to act, in part because of the initial very low knowledge scores. In addition to confirming this result, students and teachers also mentioned ways the program improved their teamwork, communication, and interpersonal skills. Students reported that they found the carbon footprint exercise surprising and motivated them to change daily habits by eating less meat and driving less. The final mission engaged teams in school or municipal actions, which increased their self-efficacy. One student commented, "I learned that there are not only solutions for individuals, but that much more can be done at the community level" (Kolenatý et al., 2022:10). Correlation analyses suggest a strong and positive relationship between knowledge and climate concern, climate concern and self-efficacy, and concern and willingness to act. Knowledge about climate action is correlated with self-efficacy and willingness to act.

A structural equation model was developed from the data that suggests increasing climate knowledge can increase climate concern, which can lead to increases in self-efficacy and willingness to act.

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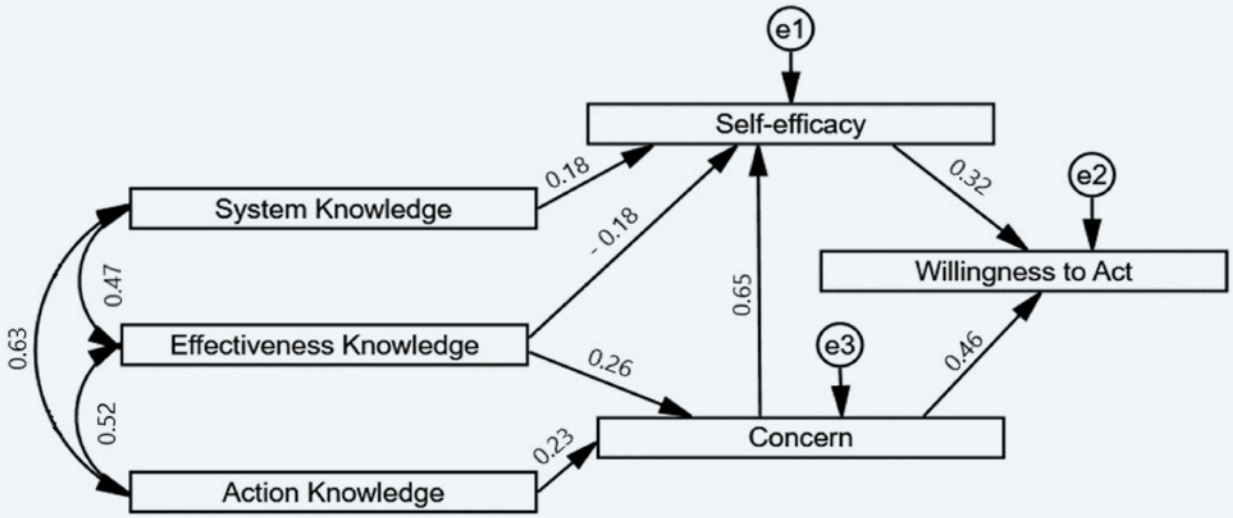

The length of the CO2 League program enables youth to work with the complexity of climate change, uncover misconceptions, and take local and meaningful actions. The school provides resources and a common foundation for interacting, without removing time and attention from academic standards in the curriculum. By sharing what they have learned with others, participants gain confidence and self-efficacy as climate communicators and others gain information. Interaction with municipal leaders in Mission 4 builds political empowerment. Repeating the program in the same school may, over time, enable others to begin to accept youth voices for change.

(From Kolenatý et al., 2022)

Third, while we all know we need to launch a myriad of actions, most of them will not be easy. Individuals, communities, and society at large can begin by taking small steps toward change (Weick, 1984), building confidence, and growing toward both individual and collective action. It is easier to start with small steps in the comfort of a nurturing atmosphere, and an educational program can provide that support. The process of practicing action builds action-taking skills, and this practice can be scaffolded to start small and expand in time. The young people in the Boys and Girls Clubs who led community projects in tree planting and information exchange, for example, acknowledged emotions of worry, anger, and sadness, but also explained that it was important to them to work together on a project because they were making a difference (Trott, 2019). Increasing the intention for civic engagement doesn't require action projects, however. Classroom civic discussions that expose students to exploring options, valuing diversity, and assisting in defining rules increase the perception of fairness in the school climate, which also supports youth positive development and civic engagement (Lenzi et al., 2014).

Fourth, youth are demanding climate action education. According to some young climate activists, the process of organizing a school strike gave them an opportunity to learn more about climate change, learn how to communicate the issue to their peers, and realize how little their schoolwork prepared them to understand climate change and do something about it (Verlie & Flynn, 2022).

In Austria, school strikers demanded improvements to the school curriculum and a follow-up survey documented the changes they would like to see, including better teacher preparation (Winter et al., 2022). Strikers in New Zealand became more aware, then anxious, as they learned about climate change. Some students turned that fear into anger, especially at injustice. They called for legislative action as well as improved education (Bright & Eames, 2022). Young climate activists in the United States described their school-based climate education as inadequate, narrowly focused, or absent and recommended required climate education for all ages that addresses climate justice and motivates action (Trott, 2024). Interviews with young climate activists in California report that they learned about climate change through school. Their education framed the issue as abstract and irrelevant, however, without any strategies for addressing it. They felt a sense of immobilizing dread about the future (Neas, 2023).

Finally, climate education that focuses on climate science without climate action can backfire. Young climate activists report that they are tired of hearing how bad climate change will be and how it will be their job to solve the problem. Those messages are debilitating, depressing, and frankly untrue (Bright & Eames, 2022; Trott, 2024). The severity of climate change is a function of what we do now, and there is work that all of us can tackle now, without waiting for today's youth to tackle them in the future. Including hopeful solutions, strategies for taking action, an awareness of those who are most vulnerable, local governance systems, and ideas for climate equity are important elements that must complement climate science to create effective climate education for youth as well as adults.

> *One climate activist in New Zealand said, "'I would rather be educated about what is happening in the real world and then do something about it. All emotions are motivators; it started off as anger and turned into anxiety, then I thought I had to do this.'*
>
> (From Bright & Eames, 2022, page 23)

Types of Actions that Matter

What does the research tell us about how climate education can successfully promote both individual and collective climate action? Are some actions more helpful than others? Drawing from studies across formal and nonformal settings, we can categorize and analyze different approaches to engaging learners in climate action. Stern's organization of pro-environmental behaviors (Stern, 2000) has been a popular way to organize pro-environmental actions, but it focuses primarily on what individuals can do and blends private actions that are truly private with those that are public. There are a variety of ways people organize environmental actions (Carman & Zint, 2020). Thinking about the motivations that prompt various behaviors suggests the following suite of actions, each of which has been used by educators to prepare learners for taking action.

Although people should have the opportunity to choose what actions to take that they are able to implement, it is helpful if learners realize some behaviors have a greater impact on greenhouse gases than others. Project Drawdown **(https://drawdown.org**) calculated the greenhouse gas emissions that could be reduced or sequestered through the implementation of over 90 changes. Many require industry compliance (e.g., reprocessing refrigerants or installing offshore wind turbines), which suggests ways citizens could request change, make more environmentally friendly purchases, or boycott products. Other changes will not be successful without individual action, such as expanding plant-based diets and reducing food waste (Hawken, 2017). Such analyses direct learners who want to take action to a selection of targets that are most valuable and encourage everyone to reflect on their own behaviors.

For education that focuses on climate action to achieve the goals of action competence, however, the focus should not be on completing the project, but on building the skills in the process of taking action—learning about alternatives, considering consequences, weighing choices, and making decisions. Group projects provide opportunities for important skill development, such as teamwork and leadership. The type of group project also enables learners to gain specific information, for example, information about habitat enhancement or civic processes, depending on the project.

Individual Actions

Much of education is oriented around preparing individuals for their future—for making good decisions, for understanding concepts, for thriving in their community, and for choosing a career. In keeping with that emphasis, environmental educators have a strong legacy of encouraging learners to consider individual pro-environmental behaviors. Many of these are also appropriate for climate actions.

Individual Private Actions

World attention on global temperatures and international treaties belies the important role of individual behaviors. While these actions alone will not reverse global warming, if everyone who could implement a suite of specific household actions did so in the United States, the reduction in carbon dioxide emissions could exceed the total national emissions of France (Dietz et al., 2009). These actions include purchasing energy-efficient appliances when it is time to replace an old one, reducing the temperature of household hot water, checking tire pressures, and weatherizing the home. Most of these actions are private, not actions that neighbors would know about. The motivations for taking these actions reside in the domains of awareness, knowledge of the consequences, ability to undertake the actions, one's sense of personal responsibility, and belief that these actions matter. Some individual private decisions can also be in the public sphere, rather than the household, such as how a person votes on an issue or candidate, or whether someone gives money to an NGO. Since community norms can powerfully affect individual behavior, organizers have found ways to make these actions public, such as providing "I Voted" stickers or publishing the names of contributors at various funding levels.

Individual Public Actions

Many actions that reduce carbon emissions are visible to others, for example, the car a person drives, the foods they eat, and the clothes they wear. McNeill and Vaughn's (2012) review of high school students' knowledge and agency revealed that understanding climate change was not sufficient to trigger agency. Classroom lessons should clearly show how personal choices shape environmental outcomes—and how those effects multiply when many people make similar choices. Educators first need to help learners understand that lifestyle decisions affect climate change by teaching about product lifecycle and externalities. Carbon calculator and ecological footprint activities help educators make these connections more obvious to learners. For many people, the role their hamburger or solo drive to work plays in climate change is too complicated to assess, though they might realize that both involve more greenhouse gas emissions than grilled cheese or

> *A majority of course graduates reported pro-environmental decisions (i.e., type of car to buy, food choices) that they attributed at least in part to experiences gained in the course. Furthermore, our carbon footprint analysis suggests that for the average course graduate, these decisions reduced their individual carbon emissions by 2.86 tons of CO2 per year. Surveys and focus group interviews identify that course graduates have developed a strong personal connection to climate change solutions, and this is realized in their daily behaviors and through their professional careers.*
>
> (From Cordero et al., 2020, page 1)

Box 7: University Course Affects Climate-Related Decisions Five Years Later

Faculty at San Jose State University in California developed an intensive two-semester course on climate change. Recognizing the importance of climate change and the potential for individual behaviors to impact carbon emissions, they used the environmental education literature and the Environmental Citizen Model (Hungerford & Volk, 1990) to identify educational strategies that could influence the adoption of new habits. They designed a 9-credit course to be taught over two consecutive semesters by faculty from three different departments with complementary expertise (climate science, climate mitigation, and environmental communication). The significant time investment enabled the course to affect students career choices and personal habits, deepening the personal relevance of climate change, and developing ownership for change.

The course content included understanding factors that affect climate and models that explain the changes that are due to human activities, policies and actions that mitigate climate change, and marketing climate messages for various audiences. Several assignments were critical to supporting behavior change. They were asked to write a paper about the importance of climate change in their career field. They used an online carbon calculator to assess the carbon emissions associated with their lifestyle, implemented a carbon reduction plan for a week, and reported on this experience. A United Nations-style climate negotiation simulation enabled students to gain the perspectives of vulnerable nations. A community action project stretched across both semesters and enabled students to form teams, develop proposals, and implement an activity that affected climate change in a local community. Projects included developing community gardens, giving climate lessons in schools, and campaigns to influence climate action among local businesses.

To evaluate the effectiveness of the course, an online survey was sent to the 500 students who took the course between 2007 and 2012; 104 responded. Their comments were used to frame focus group questions and conducted two group interviews (n=5). Researchers also calculated the carbon emission impacts of the choices respondents have made that they credited to the course.

The most interesting findings of the evaluation are:

- Respondents had stronger climate beliefs than the general public: 83% acknowledged the scientific consensus on global warming, believed it would affect their lives, and personally experienced the effects.
- Students reported taking a variety of actions that conserve energy and attribute them to the course: 95% recycle more often, 86% use energy efficient light bulbs, 75% donate products for reuse, 64% choose products that have less packaging, 59% purchase energy efficient appliances. 80% reported the course changed some of their food choices.
- By estimating the reduction in carbon emissions for all of the changes that respondents reported were due to taking the course, authors calculate the average reduction was 3.54 tons of CO2 per year per person, though the range varied from very little (0 to 1 ton per year) to quite a bit (6 to 8 tons per year).
- Those who believed global warming will harm them personally and future generations had a larger reduction in carbon emissions than those who did not. The focus group participants agreed, "the knowledge of climate change gained in the course prompted them to think about the impact of their actions" (page 11/23). They believe their new habits are part of the solution to climate change.
- Focus group participants also explained that the community project enabled them to solidify their understanding of climate change and climate communication.

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The authors calculate citizens in California during the same year reduced their carbon emissions by 0.68 tons per person, suggesting that the impact of the course was to reduce emissions by 2.86 tons per student per year. If secondary and university students in middle- and high-income countries were given an opportunity to take a similar course, climate education could reduce emissions by 18.8 GT of carbon dioxide by 2050, an amount larger than Project Drawdown's estimate of the impact of offshore wind or electric vehicles.

(From Cordero et al., 2020)

"Now I'm a vegetarian, and I've stuck to it. I feel good about how I'm living my life, and I'm excited by all the changes that I'm making, and I will continue making these changes because they make me feel great."

—Lolitta, focus group participant, page 12

"Those [community] experiences, I think for me, I carry those longer than/ more than being in the classroom. . . . Being with people, doing something that's going to translate into what I have to do work-wise in the future, [was a] translatable experience to the workforce."

—Billy, focus group participant, page 12

Two studies provide evidence that these lessons are effective. After exploring their carbon footprint in the after-school program, CO2 League, in the Czech Republic, participants reported, "I try to recycle more waste, or buy second-hand things, or reduce eating beef and eat more chicken meat, for example" (Kolenatý et al., 2022, p. 9; see Box 6). Similarly, Cordero et al. (2008) used the ecological footprint to reduce misconceptions and reinforce students' personal connection to climate. A survey of university students five years after taking a one-year course on climate change confirms that education can change behavior (Cordero et al., 2020; see Box 7).

There are drawbacks to a focus on individual action. In a recent systematic literature review, Morrissey-Gleeson and Morrissey (2024) caution against an exclusive dependence on individual actions. Learners may naively believe these are the only or best way to mitigate climate change, and then become depressed at the scale and scope of global climate change. A focus on what individuals can do should be accompanied by an emphasis on what governments and industry are doing in their work to transform society. In addition, the role individuals can play in nudging governments and industries is critical (Hundemer et al. 2026). Skamp et al. (2013) suggest emphasizing the value of indirect individual actions, such as support for taxes and international agreements to create emission-reducing policies.

Collective Actions

When people work together to accomplish a task, the act of listening, negotiating, leading, summarizing, and navigating the process of completing their goal can help build important skills, and is even more likely to do so if this is purposeful. Not only do learners gain self-efficacy and confidence in their own abilities, their improved communication and group process skills build collective efficacy. These are the 21st-century skills of collaboration, communication, critical thinking, and professionalism (Kennedy & Sundberg, 2020). Project participants come to believe they can work with others to achieve what may not be possible alone. Teachers use projects in the classroom to build these skills and demonstrate the value in working together.

There are barriers to conducting any project in a public school, of course. Short class periods, an emphasis on content, competition for grades and scholarships, graduation exams, teacher accountability, and state standards conspire against long-term action projects (Ardoin et al., 2023; García-Vinuesa, 2024), making out-of-school contexts often more hospitable to time-intensive, project-based learning (Kolenatý et al., 2022; Trott, 2021). Such approaches fit into four different categories: actions to inform others, ecomanagement actions, school or workplace civic actions, and community civic actions.

Actions to Inform Others

Educators often ask learners to make a poster, give a presentation, or create a public service announcement to share information they have learned. This strategy has two potential benefits. It enables the educator to assess what has been learned. In addition, if others see the poster or listen to the presentation, it might increase their climate awareness in a ripple effect. For example, the middle and high school youth in the CO2 League shared information with schoolmates about ideas to reduce carbon emissions (Kolenatý et al., 2022). A university course deftly blended climate education with media literacy and asked students to create public service announcements that addressed misconceptions and provided scientifically accurate information (Rooney-Varga et al., 2014). Several programs have put young people behind the camera to create photographic exhibits (Trott, 2021), digital stories (Finnegan, 2023b), and documentary films (Littrell et al., 2022) to raise awareness among the public about climate change impacts. In these cases, increasing climate literacy was only one outcome of the project, since the process of doing a project and teaching others increased efficacy, pride, and hope.

> *Qualitative analysis of student experiences revealed high levels of intrinsic motivation and engagement with the project, critical thinking, social learning, an interest in climate change that reached beyond the course, and a sense of empowerment and agency.*
>
> (From Rooney-Varga et al., 2014, page 598)

> *The thing about Green Ambassadors that is so powerful to me and I love it is because we get to do the solutions-– it's actually youth empowering youth because we're in charge of it.*
>
> —Youth advocate
> (From Bandura & Cherry, 2020, page 949)

Some educators seek to teach parents as well as children, in the hope that information they cover about current environmental issues and pro-environmental behaviors will find its way to dinner table conversations and family decisions, particularly in households that might not accept the scientific consensus on climate change. This is not something that happens automatically, but it can be designed into a unit by adding homework assignments (Duvall & Zint, 2007), such as a student-led interview about changes in local weather. In a clever experiment, Lawson et al. (2019) designed a climate unit consisting of four classroom lessons and a service-learning project for 15 middle school teachers. Participating youth significantly increased their climate change knowledge as a result of the lessons and sparked greater concern for climate change among their parents than those in the control group. The lessons focused on local impacts of climate change in an area recently flooded by a major storm, which might have made the information salient to even conservative families. In another example, teenagers in a charter high school in California provided their peers with information about the difference between fossil fuels and renewable energy and the ways people can reduce greenhouse gases. They worked in their school to reduce food waste, shut off unnecessary lights, and compost remaining food waste (Bandura & Cherry, 2020).

Ecomanagement Actions

Some learners and educators are eager to get their hands dirty. Planting trees and gardens, and cleaning up a stream are popular, physical, and typically non-controversial projects that educators use to engage learners in improving their community. These projects are valuable—but simply having students plant tree for Earth Day, for example, does not, by itself, build action competence. With all projects, the best learning occurs when learners identify projects they are interested in pursuing, listen to local experts, identify locations for their work, and plan how to make it work.

Because climate change affects nearly every environmental issue, youth can address food security, transportation systems, endangered species habitat, or recycling in a hands-on project and justify their actions as mitigating or adapting to climate change. Earth Force offers a time-tested model of environmental action civics (https://earthforce.org) that educators can follow to empower youth with action competence. For example, students in Montana organized noxious weed pulling groups to reduce the chance of wildfire and give the native plants a chance to grow (Earth Force, 2024). A 4-H club using a shorter version of the Earth Force program, Community Action Projects for the Environment (CAPE), created a pollinator garden and made videos to help community residents do the same (**https://programs.ifas.ufl.edu/cape/**).

Others are also seeking nature-based solutions, to build both resilience to climate-related disasters and protect habitat. A large homeowners' association in Texas, the Valley Ranch Association, is now a certified community wildlife habitat, thanks to their environmental club and the National Wildlife Federation. Residents of one street in Ardmore, Pennsylvania, have worked together to reduce pavement on driveways, remove turf, and create rain gardens (Buckley & Einhorn, 2025).

School or Workplace Civic Actions

One strategy for empowering youth to be change agents and to experience the ups and downs of implementing a project that seeks to mitigate or adapt to climate change is to consider how to change the school building or property (Anderson, 2012). When limited to the school, these projects could be more feasible and appropriate for younger students or in contentious communities. Schools can become a "living laboratory" where climate actions are demonstrated, supported, and promoted (Otto et al., 2020). The concept of making schools more climate resilient has been widely advocated in international documents (see Appendix A). The benefit of these projects is that skills and collective actions to make change can be practiced in the relative safety of the school environment. The Youth Climate Action Toolkit (K12 Climate Action & The Nature Conservancy, 2024) features many of these actions that can be implemented at a school. Furthermore, these projects are good practice for learning about governance and decision-making. In most cases, students learn to make compelling requests of decision makers—a strategy that can serve them in a variety of contexts.

Using the Earth Force model, students in Rachel Carson Middle School in Virginia worked with teachers and administrators to reduce plastic waste with water bottle refill stations, reusable water bottles, and reusable shopping bags. To keep their local stream clean, students in Hunters Woods Elementary School, also in Virginia, raised awareness about the impacts of erosion and installed native plantings and a rain barrel at school (**https://earthforce.org/category/action-stories/**). Others at a high school developed a composting program to decrease food waste at their school **(https://earthforce.org/2022/08/young-people-reduce-food-waste-at-their-new-york-school/**).

Adults can take the same strategies to effect change at the workplace, supporting native plant gardens, incentives to carpool, improvements to energy efficiency, and reductions in food waste. The Dead Silent Lawn Care company in Athens, Georgia, takes a quiet approach, using electric equipment for all of their lawn maintenance tasks, reducing fossil fuels, and contributing to neighborhood serenity **(https://www.deadsilentlawncare.com).**

> *It is not enough to integrate relevant knowledge such as environmental and climate change education into curricula. Education should also cultivate the necessary skills for climate change education, within the larger context of twenty-first century lives and livelihoods: critical thinking; problem solving; and collaboration across all subjects and in the development and maintenance of safe and sustainable schools.*
>
> (From Anderson, 2012, page 195)

In addition to workplace changes, many other groups are taking action in places where they gather. Faith groups, for example, have been able to reduce carbon emissions and save money through building modifications and supporting their community.

A Lutheran church congregation in Trenton, New York, added solar panels to their church's roof, Muslims gathered for eco-conscious potlucks, while others worked together to support community goals, such as the Harlem Congregations for Community Improvement that boasts a Green Grid Roofing system (**https://www.americanprogress.org/article/21-ways-faith-groups-are-combating-global-warming/**). See also Caldwell et al., 2022 for an analysis of environmental activities of faith-based communities in Toronto.

Community and Policy Civic Actions

Most school systems have an overarching mission to prepare youth to become active and responsible citizens. This may be achieved through service-learning programs or civic education courses that develop critical thinking about democratic participation and governance. Climate education that includes a civic action component may involve group projects that address community decision makers, cultivating civic engagement, or "working to make a difference in the civic life of our communities" (Ehrlich, 2000, page vi). To promote action civics, several youth organizations funded an effort to categorize the types of community contributions youth made through their action projects—such as participating in fundraising or deciding how to distribute funds, meeting with public officials, publishing booklets, conducting an awareness campaign, or working toward a policy change (Gingold, 2013). They recognized that affecting community policies is a critical lever, along with working on communication or ecomanagement projects.

The Earth Force model is designed to guide learners to understand how decisions are made, explore stakeholder interests, find partners in the community, and make a request for change. Following this model, students in Charleston, South Carolina, returned year after year to request a pedestrian path over a new bridge and after seven years achieved success. The president of the local bicycle advocacy group, who was so impressed with the traction young people gained, said, "I will never again take on an environmental issue without involving young people" **(https://earthforce.org/2024/09/students-advocate-for-equity-in-charleston-sc/)**. Similarly, middle school students in Colorado engaged state officials to advocate for better building practices in the wildland urban interface to protect residents from wildfire. The new legislation was signed in 2023 **(https://earthforce.org/catgory/action-stories/)**. In each of these examples, youth became involved in how decisions are made in their community through partnering with the organizations and committees that do this work.

An evaluation of Community Action Projects for the Environment (CAPE), which was modeled after Earth Force, assessed how youth perceived their club projects and if outcomes depended on the type of project they selected. Some clubs chose a communication campaign that involved making videos or an exhibit; the goal was to raise awareness about an issue. Youth working on these projects tended to say their favorite and most successful elements of the CAPE program were making friends and working together. The groups that launched projects to change a local policy or speak at meetings with community members. The young people in these groups tended to most appreciate the power of talking to civic leaders and seeing their efforts acknowledged by others. Furthermore, their civic engagement scores were significantly higher than those youth who undertook communication projects; they believed they could make a difference (Odom, 2023).

In many cases, young people are motivated to take action without educators facilitating the process. Three 9-year-olds in Lexington, Massachusetts, persuaded their town council to overturn a law that prevented solar panels on town buildings. The council proceeded to install panels on their buildings (Bandura & Cherry, 2020). These champions continued to suggest more actions, which led to their school adding solar panels and protection for a nearby forest. Their comments echo a number of themes noted by researchers: small wins motivate people to additional projects, engaging in action can shift feelings of despair toward hope and efficacy, and working in teams strengthens collective confidence in accomplishing change.

The School Strikes for Climate movement (also known as Fridays for Future, the youth-led actions that arose in response to Greta Thunberg's protests) is another example of a team project as well as youth activism. These groups are rarely teacher-led or school-sanctioned.

Preparation and planning are generally conducted by students after school, while the actual strikes take place during school hours. Participating students recognize that they learn a great deal through the process (Bright & Eames, 2022). A systematic review of 51 papers exploring student climate activism revealed that through their participation in climate activism, students learned about climate change, developed self-efficacy and empowerment, and created new opportunities for social connections (Neas et al., 2022).

> *We had more power than we'd ever imagined in our wildest dreams. We weren't just helpless girls. … It really changes you. … Working as a team, it gives you much more courage than if you're working as an individual. If you're alone it's always scary.*
>
> —Youth advocate
> (From Bandura & Cherry, 2020, page 949)

Research-Based Aspects of Effective Climate Education

We know a great deal about effective climate education, based on decades of work in science, environmental, and sustainability education. Through these best practices, educators can provide a comprehensive program that provides knowledge, builds understanding, nurtures motivation, and empowers skills that prepare learners to mitigate and adapt to climate change. A full review of relevant research in science education, environmental education, sustainability education, and civics education, while very relevant in their support of effective climate education, is beyond the scope of this report. While preparing for this report, however, we found numerous studies that examine successful approaches that provide new insights into what might make climate education just a little different than other issue-based programs: integrating climate education across disciplines and issues, engaging people emotionally, building action competence skills, and preparing a new workforce.

Interdisciplinary and Applied Learning

For many teachers, climate change is not specified in their curriculum (particularly social studies teachers), even though a myriad of examples of economic impacts and policy opportunities are available to cover climate through traditional concepts (Foss & Ko, 2019; MEECE & NAAEE, 2022). By using these examples, educators can integrate climate change into existing curricula and begin to make such discussions commonplace.

There are many resources to use in non-science subjects to teach about climate. Several programs provide lesson plans that convey typical subject-driven objectives while using a climate context. Here are a few examples:

- Climate Action Through Education (CATE) was developed at MIT for both science and non-science teachers in high schools. Language arts classes explore vocabulary such as the term anthropogenic and read climate change fiction, while math classes calculate and graph global carbon emissions. Teachers can compare their state's emissions to those of another state, and the costs of charging an electric vehicle at home (https://cate.mit.edu/about and **https://news.mit.edu/2023/education-climate-change-0322**).
- Another innovative interdisciplinary approach comes from Reynante et al. (2024), who developed "engineering fiction," an intervention for high school students that combined engineering design principles with climate fiction writing. Through a series of ten 80-minute lessons, students collaboratively planned and wrote stories about a climate justice problem in the future. The researchers analyzed student stories and reported that blending concrete problem-solving approaches from engineering with creative storytelling appeared to help make climate change more tangible and immediate for students.

- The organization Subject to Climate **(https://subjecttoclimate.org)** provides resources for educators in grade clusters of K–2, 3–5, 6–8, and 9–12, as well as research reports on current events. Topics such as food and transportation illustrate math, language, and science objectives while building skills to recognize misinformation and think critically. Adults benefit from climate science information, prompted by an exploration of interactive data visualizations (called mini data sprints) to increase knowledge and support concerns about climate change, thus enabling people to participate in climate conversations (Watson et al., 2024). A computer-based quiz increased high school students' interest in learning climate science facts (Thacker, 2024).

As with other science-based social issues, discussions about solutions to climate change often involve controversy, which can require students to engage in moral reasoning and value judgment. Many science teachers do not feel comfortable broaching these discussions in the classroom. And, while many social studies teachers may be better equipped to address controversial issues, they may not be comfortable with the environmental and scientific content. Working together to team teach a climate unit or stagger course information so students can use information from one class to inform another could help advance student learning. Unfortunately, a survey of over 1,000 social studies teachers in Pennsylvania found that most do not teach about environmental issues because they feel these issues are better covered in science courses, they lack comfort and knowledge, the issues involve political controversy, and the curriculum is already overcrowded (Kissling & Bell, 2020).

The importance of using climate change to address the existing state standards in non-science subjects cannot be overstated. If reading and math skills are emphasized in state tests, climate change can provide an interesting and valuable context. Language teachers can explore stakeholder positions, persuasive writing, and poetry with climate excerpts. Similarly, interpreting graphs and charts or understanding exponential growth can be illustrated with climate data in a math class. In social studies classes, it may be revealing to compare the societal costs of not taking action to the costs of implementing a climate adaptation project, such as raising a roadbed or elevating buildings that are repeatedly flooded. All subjects can explore climate—and the different disciplinary perspectives can increase learners' system-level understanding of the issue.

Climate at the Intersection

Climate affects seasons and weather, and these, in turn, affect all life on earth. The impacts of climate change reverberate across nearly all ecosystems and environmental issues. Forests and wetlands sequester carbon, which mitigates climate change, but rising temperatures, insufficient rainfall, and increasing human population reduce their capacity to do so. Some species' (often non-native species) ranges are expanding to more preferred climates while others are shrinking. Pests and diseases are likely to move beyond their traditional boundaries, threatening agriculture and human health. Water, the lifeblood of farms and cities, may be less available in some places, while floods rage across others (IUCN, 2022; UN, n.d.). Climate change plays a role in most current environmental issues and is part of emergency preparedness planning, strategies to protect biodiversity, and policy conversations that guide transportation, land-use planning, and building construction in every community. As with many cross-cutting issues, climate can be integrated into learning in countless ways—but it's just as easily overlooked when educators assume it's being covered elsewhere. Yet the opportunity to engage diverse audiences by connecting climate to the issues they already care about is especially compelling.

Engaging Emotions

Addressing young people's mental health has been an important element of climate education research. An analysis of letters to the next president in 2016 illustrated the depth of concern among 350 middle and high school students. Three themes emerged: solutions, politics, and doom (Zummo et al., 2020), suggesting that despair preceded and fed the era of school climate strikes. Several large, comprehensive studies echo these findings. A survey of 15,790 young people in the United States reports 85% of the participants are at least moderately worried, with 58% being very or extremely worried about the impacts of climate change (Lewandowski et al., 2024). Exposure to severe weather events increased

climate distress and their desire to act. Responses from 10,000 young people in 10 countries also report 59% are very or extremely worried and 84% are at least moderately worried (Hickman et al., 2021). Respondents believe government responses to climate change betray, rather than reassure them. A recent survey of 512 secondary students in the United Kingdom suggests that holding a negative view of the future can fuel both anxiety and hope, and both can drive collective and individual actions (Finnegan, 2023a). Both hope and action competence, however, decreased with age from 16 to 18 years old.

A meta-analysis of 46 quantitative studies that explored the relationship between hope and climate engagement suggests that it is not a straightforward correlation but depends on the source of the hope. When respondents are hopeful because they believe climate change will not be a problem, they report less engagement. When respondents' hope is defined as the possibility of taking action, they report greater engagement. General hope was weakly but positively associated with greater engagement (Geiger et al., 2023). Ojala suggests that survey items need to clearly distinguish between general hope and similar constructs, such as self-efficacy, uncertainty, optimism, inspiration, and constructive hope (Ojala, 2023). Parallel surveys in the United States and six European nations found that those who hold stronger emotions were more likely to take climate action (Kovács et al., 2024).

Interviews with three young climate justice activists in Canada suggest that group-based opportunities to work on climate justice were critical to feeling hopeful and purposeful about climate change (Vamvalis, 2023). Similarly, negative emotions of fear, worry, and sadness were overcome by pro-environmental attitudes, a sense of urgency, and deeper connection to nature by youth-led, group actions in after-school programs in western United States (Trott, 2021). The importance of addressing emotions also features in the popular Hands, Heart, Head model of transformative sustainability learning, by allowing youth to select the project they are passionate about working on (Sipos et al., 2008; Olsen et al., 2024).

Acknowledging the importance of hope and other emotions in climate action raises another set of thorny questions—what is the role of an educator when it comes to emotions? The good news is that classrooms offer far more than what's measured on tests. Through the way educators model behavior, choose readings, bring in guest speakers, set class norms, and guide conversations, they can acknowledge students' emotions and help build the ones that support climate action. Educators should first reflect on and understand their own level of eco-anxiety, and then work with their learners (Pihkala, 2020). The Climate Emotions Toolkit for Educators (NEEF & CMHN, 2025) includes an educator's guide, meditations, and student activities. Educators can learn more about addressing grief, loss, trauma, anger, and depression, which can help them support students. Elements of hopelessness, meaninglessness, worry, and concern can be countered with activities and reflections designed to nurture coping skills and connection to nature. Engaging students in problem solving and collective action projects is another strategy that can be used (Pihkala, 2020). Both problem-focused and meaning-focused coping strategies are positively associated with pro-environmental behavior (Ojala & Bengtsson, 2019). Understanding why students hold various emotions should also help guide how educators address climate emotions in a group setting. Learners can be angry and frustrated at the perceived lack of attention or the perceived ill-advised attention to climate change if they reflect the partisanship of adults.

Some emotions may be strengthened through lessons designed to enhance cognitive skills. A research study in Washington state added systems-thinking and multi-species caring outcomes to their evaluation of a ten-week high school biology unit on data visualization through a project on climate change and sea star wasting disease. The results show an increase in concern, agency, and responsibility for a variety of organisms affected by climate change, not just sea stars. Authors suggest these broader outcomes were the result of opportunities in the unit for community engagement and action (McGowan & Bell, 2022).

Acknowledging and voicing one's fears and concerns can be a first step toward mental health. Finnegan (2023b) recognized this opportunity by asking youth to create short videos. This exercise in digital storytelling captured creative, emotional, and sensory stories about the future. Some videos were decidedly negative (destruction and nostalgia for

what is lost), some positive (green technology and behavior change), and some nuanced (resilience and transition). In the collective viewing and discussion of their videos, some youth said the process made them more optimistic, though still worried.

Stepping Stones to Action Competence and Civic Engagement

It is difficult to separate the process of building action competence (Jensen & Schnack, 1997) from implementing action projects. Action projects build competence, and competence-building exercises typically involve action projects that engage learners in skill development, a pedagogy called action-oriented education.

A 4- to 6-week unit that included an 11-lesson module on energy and climate for high school students led to a significant increase in climate understanding. While a majority reported adopting actions to reduce their impact on the climate, these were the students who also believed their actions could make a difference (McNeill & Vaughn, 2012). It is essential that students learn about the effects of their actions if they are to develop agency and efficacy.

Inner Development Goals **(https://innerdevelopmentgoals.org)** used research and practice in the field of human development to identify transformational skills for sustainable development. Their framework involves five key dimensions that often appear in educational programs (Ardoin et al., 2022): Being—relationship to self; Thinking—cognitive skills; Relating—caring for others and the world; Collaborating—social skills; and Acting—enabling change. Each dimension further delineates four to five skills, for a total of 23 skills needed to achieve a more sustainable future; these are strategies that effective educational programs should include (Jordan, 2021). These goals were recently used to create the Transformative Skills Guide, which focuses on how the goals can be applied specifically to climate literacy. The Guide offers examples of how educators, communicators, and practitioners might develop specific skills or abilities in others and how someone might express or demonstrate those skills **(https://www.climateliteracy.earth).**

Skills associated with civic engagement can be nurtured in a democratic school climate, which is characterized by perceived fairness from teachers in discussions of current, civic issues (Lenzi et al., 2014). Teachers who are comfortable addressing controversy in the classroom prioritize creating an inclusive environment so that students feel respected and able to express unpopular opinions. They use techniques such as role-playing, analyzing different perspectives, exploring real scenarios, and challenging assumptions with clear guidelines and active listening (Karousiou et al., 2025).

Because research articles only report on what the authors decided to measure, the literature can be limiting in terms of what education can achieve. For example, citizen science projects have been shown to enhance participant knowledge, environmental attitudes, community connectedness, and environmental stewardship (Ballard et al., 2024). In one study of citizen science projects that focused on climate, students who collected and analyzed phenological data learned to think more critically about data collection and increased their environmental engagement (Mitchell et al., 2017). A systematic review of citizen science programs suggests such programs identify and affect individual learning outcomes (such as knowledge and skills) more frequently than collective climate action (Groulx et al., 2017).

Civic education to promote the development of citizens who are actively engaged in their democracy has a long history in public schools. Evaluations of courses and school programs offer little guidance (Manning & Edwards, 2013) as results are strongly dependent on how the course is delivered. A systematic review of citizenship education programs evaluated with controlled trials confirmed that whole school approaches, teacher training, and participatory methods positively affect civic attitudes and behavior (Donbavand & Hoskins, 2021). A study at a midwestern university found students in a social justice course that featured intergroup dialogue gained in political participation, civic engagement, and multicultural activism; students in a parallel lecture-based course did not increase their civic engagement (Krings et al., 2015).

An example from Colwood, British Columbia, shows both the promise and the challenge of this kind of approach (Mitchell et al., 2015).The city partnered with a middle school on an environmental education

unit to support its solar hot water initiative and promote energy and water conservation. Students gained knowledge through class activities, visioning exercises, and field trips, but parents didn't engage (Duvall & Zint, 2007). It's unclear whether the city supported the effort with its own outreach or simply expected students to pass the message along. The effort had potential, but stronger links between the classroom, parents, and the broader community were needed. Lawson and colleagues demonstrated what this can look like: their program combined four classroom lessons with home-based assignments and a service-learning project—and even with just four lessons, it increased parents' concern about climate change (Lawson et al., 2019).

Building a New Workforce

The changes that will transform our society into low-carbon communities will impact every sector of our economy (Martinez-Fernandez et al., 2010). As a result, the new workforce will build much more than wind machines and electric cars. All industries will have to adapt, from apparel and building construction to farming, public health, and finance (Domeika et al., 2023). An analysis of this transition for each industry estimates that the shift to a green economy will account for $10.3 trillion of the global GDP by 2050 (Richard & Lambert, 2023). Green jobs are defined by the U.S. Department of Labor as jobs in businesses that create products or provide services that benefit the environment and jobs that engage workers in making the business more environmentally friendly (USBLS, n.d.).

Student interest in and concern about the environment has helped drive the development of coursework and degrees in sustainability across higher education. Modeled on the United Nations Sustainable Development Goals, these programs blend economic and justice orientations with environmental science to address multi-disciplinary issues such as climate change to prepare the future workforce (Žalėnienė, & Pereira, 2021). Climate education has the potential to follow a similar trajectory by integrating climate education into existing courses; creating climate modules, courses, or degrees; mainstreaming climate perspectives across the curriculum; or offering team-taught cross-disciplinary courses to all students (Molthan-Hill et al., 2019). There is significant opportunity in vocational education and training as well (Albertz & Pilz, 2025).

Despite the obvious need, there are some concerns that higher education and career counseling are not prioritizing information to students about how climate change might affect their professions (Hora, 2023), nor are educational systems considering how to embed justice and equity in climate education that builds green skills (Kwauk & Casey, 2022). A systematic review in the field of career counseling suggests that regional differences should be used to meet the needs of people and businesses with an emphasis on reducing environmental impacts (Maree, 2024).

A recent report from Jobs for the Future focuses on green skills, rather than the traditional green jobs in renewable energy, to suggest that a variety of industries will need employees who can shrink their carbon footprint. Many positions will be available to those without specialized training or a college degree, effectively enabling economic advancement to a greater share of the population (Domeika et al., 2023). Expanded training programs are needed to meet the growing need, and community colleges have begun the process of preparing students for these jobs. The Community College Research Center at Columbia University hosted a symposium for industry, government, and college leaders to discuss meeting this need in 2024, resulting in a national call to action (CCRC, 2024).

Climate Justice

Some populations, particularly those on the lower end of the socioeconomic spectrum, have contributed fewer greenhouse gas emissions than others, but will be disproportionately affected by climate change because of their location or inability to invest in adaptations. Policy solutions that fail to consider how marginalized groups will be impacted may increase their burden (Ogunbode et al., 2024). Educators can include this information in their lessons and programs, in keeping with several frameworks for climate education (NAAEE, 2024; USGCRP, 2024). Focusing on the differences between developing and developed nations, however, keeps climate change at a distance from youth and emphasizes that the problem is elsewhere (Busch & Chávez, 2022); educators should also use local examples of injustice among the most vulnerable in the United States, such as those who work outdoors (e.g., farmworkers), families who cannot afford to move out of coastal flood zones, as well as the very young and old.

A global survey conducted in 2022 assessed climate justice awareness and knowledge among over 5,600 adults from 11 countries. As in the United States (Carman et al., 2025), two-thirds of the respondents were not familiar with the term and only 17% had at least a fair amount of knowledge (Ogunbode et al., 2024). Nearly 80% of the respondents, however, agreed with key tenets of climate justice (distributional and procedural justice)—that poorer people suffer more from climate impacts and that people in the most affected communities should have more of a voice in climate-related decisions. People who were younger, had more education, or held more progressive political views were more likely to hold climate-justice beliefs. These beliefs, in turn, were strong predictors of taking action on climate, even after accounting for demographic differences.

> *Aspirations for a just society can motivate individuals to engage in climate action.*
>
> (From Editors, Nature Climate Change, 2024, page 1107)

Interviews with youth who participate in or organize climate strikes are a rich resource for understanding their motivations for climate action; they typically express the importance of climate justice and believe this should be increased in their school's approach to climate education (Bright & Eames, 2022; Neas, 2023; Trott, 2024). Unlike the climate experts who base their concern on their knowledge of climate, adult climate protesters interviewed during or just after an event in September 2019 revealed their knowledge of climate science varied greatly from reading all the IPCC reports to very little (e.g., "All I know is from Greta.") (Martiskainen et al., 2020). Nevertheless, most of their motives were encompassed in the themes of acting on their concern for their family, human existence, or the environment; wanting to influence policy to enhance sustainability; or engaging with others in social change. Their motivations ranged from science to social, and they reflected the full range of values, from altruistic and biospheric to egoistic and hedonic. Given this diversity, it's hard to pinpoint a single approach educators should use to motivate climate action. What is clear, though, is that climate science alone isn't what drives people; concerns about climate injustice can also spark action.

A review of the literature on climate justice actions taken by non-professionals and non-activists found their efforts were most often in groups to create systemic change (Trott et al., 2023). A diversity of people (from children to elders) in 16 countries were represented in the 74 articles captured in this review. Climate justice action ranged from protests to community outreach programs and restoration projects. Two-thirds of the described actions were collective; over 90% occurred in the public sphere and were indirect actions (typically encouraging policy change). In contrast, a survey of secondary science teachers in Ohio revealed that teaching about climate change tended to focus on physical impacts to the environment. When they covered action, it tended to be apolitical, individual choices for mitigation, and seldom collective efforts to address adaptations or policy (Borgerding et al., 2024). Educators wishing to provide examples of what people can do to achieve change could use the climate justice lens to considerably broaden the often limited but more typical realm of individual actions to change personal lifestyles.

Audiences for Climate Education

There are many ways to strengthen climate education across North America. Working with preK–12 public schools is an obvious strategy, and could involve an emphasis on state standards, program design for interdisciplinary studies, teacher preparation, development of instructional materials, or establishment of demonstration sites for building efficiency or energy production. Colleges and universities, particularly those that prepare teachers, represent another enormous opportunity and bring additional elements of research and workforce development (CCRC, 2024). Nonformal educational organizations and institutions provide programs that enhance schools, bring specialized resources and partnerships to classrooms, offer after-school and summer programs for youth, and can promote more extensive programs than schools because they are not limited by the time pressures of a curriculum. Perhaps most importantly, they also develop programs for adults. Adult education is essential for creating policy and reducing greenhouse gas emissions in the near future. Churches and other faith-based organizations are another venue for education and action (McDuff, 2012).

Senior programs, such as Third Act, link the wisdom of elders to community education opportunities. Every workplace and government office could embark on a program to learn and consider how they can mitigate climate change. Cities, counties, and states are already developing climate action plans to begin the process of investing in infrastructure and policy changes; these processes also need educational elements that engage people in understanding and deliberating reasonable alternatives (Plate et al., 2020). Of all these potential audiences, one has substantial coverage in the literature–teacher professional development.

Box 8: Out-of-School Opportunities Make Sense

Non-formal educational programs that offer out-of-school and after-school opportunities can be valuable in a community's climate education repertoire. The outcomes from the Boys and Girls Club program in the western United States (Trott, 2019; 2022) and the Czech-based CO2 League (Kolenatý et al., 2022) point to the success of programs that occur over several months and engage youth in learning about local climate issues and planning strategies to do something to act on their concern. Even shorter programs can be beneficial. If after-school clubs cultivate an atmosphere that builds social skills, friendships, and self-confidence, particularly among adolescents, youth can gain climate literacy as well as friendships.

Researchers in North Carolina worked with after-school STEM clubs to design a three-lesson unit that reflected best practices in climate education and offered it to rural, underserved middle school youth (Gutierrez et al., 2022). Participants explained what they most appreciated from the exercises and completed pre and post surveys measuring knowledge and attitudes. The program emphasized engaging activities and engaging with STEM professionals in each lesson.

The program significantly increased participants' climate literacy while their overall knowledge remained relatively low. Because most students began the program believing that climate change was happening, this belief did not change. They most enjoyed the active and engaging activities, engaging in discussions, and exploring misinformation. The students also valued the club meetings, enjoyed using equipment, and noted that they contributed to their teams.

(From Gutierrez et al., 2022)

Teacher Preparation and Professional Development

Teachers are a special audience for climate education as they must learn not only the content of climate science but also how to convey it effectively. Many recommendations focus on better preparing teachers to deliver information about climate change. While that is certainly needed, there are also cautions and caveats in the literature that are worth reporting. Since most in-service professional development is voluntary, it only reaches those who want to teach about climate change, which continues to leave some teachers at a disadvantage. Since these programs can assume participants want to deliver effective climate education, the programs are not likely to acknowledge the powerful influence of worldviews that those who are not inclined to convey the scientific consensus would hold (Kunkle & Monroe, 2019; Plutzer et al., 2024). Both professional development programs and teaching about climate take time, which some educators report is their greatest barrier (Ennes et al., 2021).

Should teacher workshops become obligatory, their content must be carefully selected and explained. This includes incorporating ways to help educators work with the emotions that can arise when learning about climate change. To assist educators in working in this area, Finnegan and d'Abreu (2024) developed the Hope Wheel to provide cautions and guidance as teachers explore climate change with their students.

> *Learning about climate change can be uncomfortable, but in these moments of discomfort are the seeds of transformation. As educators, we do not need to have all the answers—armed with creativity and care, mindful of different perspectives and climate justice, we can all cultivate hope and equip learners with tools to navigate this time of change and uncertainty.*
>
> (From Finnegan & d'Abreu, 2024, page 10)

Without more training, however, teachers may avoid controversy to deflect the appearance of biasing students. In a study of marine science teachers using a new unit on climate change, researchers found teachers falsely presented several perspectives on climate science (sometimes dictated in their state standards) in an effort to maintain neutrality, when in fact 97–99% of climate scientists agree on the causes and consequences of climate change. Teachers also avoided engaging students in potentially divisive discussions about the implications of climate change—where perspectives should and do vary—despite holding personal beliefs that reflect the scientific consensus. Instructional materials that include argumentation and discussion are not sufficient; teachers need training in navigating controversy in the classroom productively without revealing their personal opinions (Nation & Feldman, 2022).

Studies reveal gaps in teacher preparation. Pre-service teachers struggle to incorporate action-oriented approaches and climate topics into their lesson plans, even after sustainability coursework (Wakefield et al., 2022). Authors suggest that university students need to obtain a better understanding of the root causes and complexity of climate issues to adequately convey concepts to their students. Research comparing high school seniors to pre-service teachers found both groups lacked efficacy to become change agents, with many future teachers feeling unprepared to teach beyond basic climate information, while believing that teaching basic facts will be their role (Winter et al., 2022). One critical element in pre-service education is empowering teachers to enable students to lead, as the students' degree of engagement in decision-making has a profound effect on their interest in conducting a project and their satisfaction with the outcome (Kolenatý & Činčera, 2025). It is essential that pre-service teachers learn these skills.

Teacher educators face several challenges as they attempt to create effective instructional programs for pre-service teachers. A review of theory and research lists the following seven challenges that new teachers will face (Beach, 2023, p. 507): "(1) coping with the variation in state standards and requirements related to teaching climate change in schools, (2) providing valid knowledge and beliefs about climate change, (3) acquiring positive attitudes and self-efficacy about teaching climate change, (4) providing transdisciplinary curriculum teacher preparation, (5) addressing environmental justice issues, (6) adopting systems thinking for addressing climate change, and (7) using case-study methods for teaching about organizing instruction around specific, local instances of climate change effects."

A recent systematic review of secondary teachers' perceptions and practices identified another set of common barriers to effective climate education (García-Vinuesa, 2024):

- Curriculum limitations
- Teacher competence, comfort, and worldviews shape how they approach climate education
- Time constraints in school
- Lack of funding and state support
- Level of public controversy
- Emotions associated with climate change, among students and teachers
- Underestimating the potential of education as a strategy for change
- Insufficient teacher training, both in-service and pre-service

The author continues to outline opportunities to promote actions in climate education:

- Integration of curriculum with climate change content
- Use problem-focused and solution-oriented teaching strategies
- Magnitude of the present risk to society
- Motivation and collaboration among committed teachers
- Teacher training and professional development

The Path Forward for Climate Education

Effective climate education includes climate science but must go beyond imparting scientific knowledge—it must empower learners with the skills, motivation, and capacity to take meaningful and just action. This approach recognizes the importance of addressing both individual behaviors and systemic changes, acknowledging that while personal actions matter, collective and policy-level interventions must be implemented equitably for meaningful impact. Change can happen in households, in schools, in communities, and across societal systems. Learners need education that equips them with the skills and strategies to participate in decision-making at all levels and to advocate for—and help guide—the changes we need.

The value of experiential, place-based, socio-emotional, nature-based, and action-oriented learning approaches that connect climate change to learners' experiences and local contexts cannot be overstated. Addressing learners' anxiety and nurturing constructive hope emerges as an important part of comprehensive climate education. Implementing effective climate education requires addressing teachers' own knowledge, comfort levels, pedagogical skill, and potential biases. Rigorous research provides an evidence base that not only informs best practices in climate education but also points to areas where further investigation is needed to enhance our educational strategies and outcomes.

Looking forward, climate education has the potential to serve as a change agent for broader social and economic transformation toward a more sustainable and just future. To realize this potential, several key areas require attention and investment.

These include:

- development and widespread implementation of comprehensive climate education curricula that build action competence across all levels of education;
- increased support for teacher training and professional development to facilitate civic engagement and address emotions and climate justice;
- expansion of climate education opportunities beyond formal schooling for youth as well as adults;
- support for showing how climate education fits within the broader landscape of environmental issues, such as biodiversity loss, and helping learners connect the dots; and
- integrating climate considerations into all relevant fields of study and professional training, as well as policy changes to support and mandate high-quality climate education at national, state, and local levels. Continued research to refine our understanding of effective climate education strategies and their long-term impacts will be essential to guide these efforts.

Investing in climate education is not just an educational imperative; it is a societal necessity. By equipping learners with the knowledge, skills, and motivation to address climate change, we can cultivate generations of informed, empowered Americans capable of participating in the transformative changes needed for a sustainable future. The path forward requires collaboration among educators, policymakers, researchers, and communities to ensure that climate education evolves from a peripheral concern to a central pillar of our educational systems and societal priorities. As we face the challenges of climate change, effective climate education offers a beacon of hope and a powerful tool for building competence for action. By moving from climate science to climate action in our educational approaches, we can build a collective potential of informed, motivated individuals to create a more resilient, sustainable, and just world for current and future generations.

Conclusion

This report offers a broad overview of recent climate education research and reports, aiming to capture key trends and insights while acknowledging that much valuable work remains unexplored. While not a systematic review, it provides a snapshot of current understanding and innovations in the field. The rapidly evolving landscape of climate education research demands more frequent and focused syntheses, particularly of work from since 2020. Recent innovations in teaching approaches, evaluation methods, and program design—particularly those addressing urgent challenges like climate anxiety, climate justice, and action competence—deserve exploration.

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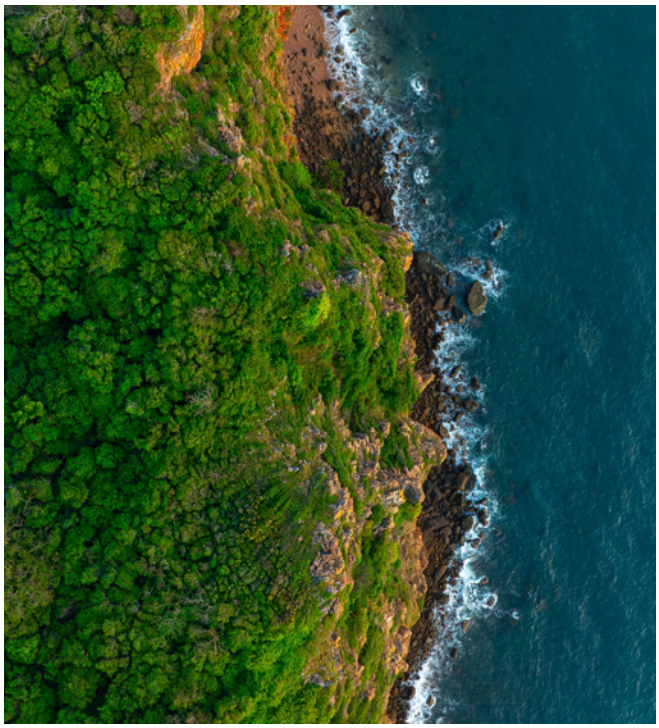
Appendix A: Reports on Climate Education

Agency	Title	Purpose and Key Points
Center for Global Development June 2024	**Climate Change and Education: Building Momentum through a Shared Research Agenda** https://www.cgdev.org/publication/climate-change-and-education-building-momentum-through-shared-research-agenda	Suggests four areas for research: • Impacts on child well-being, advance knowledge of the impacts of climate change on learning and education delivery • Solutions at scale, increase evidence on interventions in the most climate-vulnerable contexts and how these can be institutionalized • Education for adaptation, increase the evidence base around the use of education as a tool for climate action • Meaningful collaboration, promote collaboration and prioritize the leadership of climate-vulnerable country contributors
Education Development Trust 2024	**Climate Change and Education: From Evidence to Action** https://www.edt.org/expertise/climate-change-and-education/	1. Improve general levels of education to help people be resilient to climate-related challenges 2.Build climate-resilient education systems at a national level 3. Use schools as a key resource for the empowerment of local communities
FHI 360 2023	**Strengthening climate change education in the United States** https://www.fhi360.org/resources/strengthening-climate-change-education-united-states/	How to achieve change: 1. Enact policy to support climate change education at national, state, district, and school levels. Every tier of education systems must act to improve students' climate change education. Government agencies, economic systems, and political structures must also adapt to better support climate change educators and young people. 2. Provide access to high-quality curricula and materials that are grounded in scientific evidence. Climate change education must be grounded in evidence to provide young people with a foundational scientific understanding. It should build their knowledge, skills, and commitment to participating in ongoing efforts to design solutions for a changing world. 3. Support educators with training and professional development. In addition to quality curricula, education leaders and policymakers need to provide educators with effective professional development, so they have the training, resources, and confidence they need to effectively teach about climate change. 4. Scale up out-of-school time and work-based learning models. To ensure equitable and systemic access, climate education should be a core topic within standards-based classroom learning. It must also be interdisciplinary and integrated into informal and out-of-school programs, as these outlets provide youth with hands-on opportunities to learn and develop understanding in different contexts.

Agency	Title	Purpose and Key Points
UK National Association for Environmental Education June 2024	**Engaging the Next Generation: The state of environmental, sustainability and climate education in UK schools and effective practice in the classroom** **Talks, I. & Finnegan, W.** https://naee.org.uk/wp-content/uploads/2024/11/naaee-report-engaging-the-next-generation.pdf	This commissioned report is a review of the research and synthesis of effective practice in the interdisciplinary topics of environmental, sustainability, and climate education in UK schools, with guidelines for policy makers, schools, and teachers. Includes a Manifesto of 16 points, plus rationale behind each point. The four principles that are at the core of the manifesto are: • Partnerships at every level of whole-school decision-making and interdisciplinary education, including with community organizations • Integrity and being clear about values, open, and honest • Building capacity at every level, through student learning, teachers' professional development, and school development • Inclusiveness with a global approach to issues and considering equity and justice as all contribute to solutions
UNESCO and MECCE	**Education and Climate change: Learning to act for people and planet** https://unesdoc.unesco.org/ark:/48223/pf0000389801	The Global Education Monitoring Report team monitors and reports on progress toward meeting the educational components of the Sustainable Development Goals. This report focuses on the impact of climate change on education and the role of education in climate action. It suggests education must embrace social and emotional learning as well as action-oriented learning, in addition to knowledge transfer, to meet its goals. Several key messages include: • Education's role in combating climate change is not sufficient. • Climate change curriculum is not balanced, especially in social studies and elementary grades. • Education still focuses on imparting information. • More education is associated with a greater likelihood to engage in climate adaptations. • More education alone does not motivate mitigation action. • Multiple sectors rely on formal, non-formal and informal education to increase capacity for change. • Students and youth are calling for improved climate education. • Campaigns around climate change raise awareness among adults.
USAID	**Advancing Climate-Resilient Education Technical Guidance** Advancing Climate-Resilient Education Technical Guidance | ECHOcommunity.org	Guidance to USAID missions to support education in a changing climate. How to stabilize and create a resilient education system in the face of climate changes and supporting integration of climate science into curriculum, noting opportunities for green jobs, teacher training, HEI programs.

Agency	Title	Purpose and Key Points
World Bank Group 2024	**Choosing our Future: Education for Climate Action** **Sabarwal et al., 2024** https://www.worldbank.org/en/topic/education/publication/education-for-climate-action	Three sections: 1. Education for Pro-Climate Behavior Change 2. Skills for the Green Transition 3. The Impact of climate change on education and what to do about it Covers the territory from misinformation to green skills and behavior change. Biggest needs are teacher training, infusing climate into curriculum, and basic literacy



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