

# Shifting the desired outcome from climate literacy to climate agency: Education that empowers civic leaders

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## ABSTRACT

Despite improvement to the public's awareness of climate change, we have yet to achieve the necessary transformations to our planet's future—we believe that educators can and should be an influential catalyst in the shift. Educators around the world foster people with a deep understanding of climate change and the capacity to address it. In this paper, we synthesize the existing climate education literature to put forward a clear definition of the concept of *climate literacy*. We then draw attention to a significant problem with *climate literacy, agency*, which is often un- or ill-defined in climate change education scholarship, resulting in substantial impacts on climate educators' efforts. We conclude this paper by offering a reimagined vision of climate education that shifts away from acceptance of climate change to empowerment for meaningful climate action.

**Keywords:** climate change, environmental education, literacy, agency, environmental responsibility

## INTRODUCTION

Scientists overwhelmingly agree that human activities, such as transportation and electricity production, create substantial greenhouse gas emissions that disrupt natural systems and ultimately change the planet's climates (US EPA, 2023).

The consensus is that these disruptions are resulting in devastating consequences for the health and well-being of people and environments worldwide (AAAS, 2014).

Given humankind's primary role in driving climate change, it is also humankind's responsibility to take proactive measures to safeguard the planet and mitigate the worst consequences (United Nations, 2021).

While addressing climate change is a daunting task, many leaders believe that immediate and concerted efforts can lessen the worst impacts (World Economic Forum, 2022).

Governments, industries, communities, and individuals all share responsibility for maintaining a sustainable earth. This responsibility spans from endorsing carbon emission reduction policies to adopting personal sustainable habits and minimizing waste.

Every sector of society has opportunities and the obligation to address climate change, educators included (João et al., 2022; Owens et al., 2019).

## PAST VISIONS & GOALS FOR CLIMATE EDUCATION

Different stakeholders will have different pathways towards enacting climate responsibilities. Education assumes a unique role in that it can formally address the knowledge, attitudes, and capabilities people need to support and engage in a sustainable society (Bhattacharya et al., 2020). Formal schooling, in particular, provides a consistent and safe learning environment for students to explore the intricate social and scientific aspects of changing climates (Owens et al., 2019). However, such learning is not organic, and educators are required to be passionate and capable of using their position to influence public perceptions and decisions regarding climate change.

Recognizing this responsibility of educators, institutions such as the National Oceanic and Atmospheric Administration, the United Nations, and other entities advocate for a primary educational outcome of *climate literacy* (CL). However, there is little consensus on what constitutes CL across the literature. Often, different lists outline the competencies and qualities that characterize a climate-literate person. To lay the groundwork for this paper, we first brought together several of the most prominent perspectives on CL, including leading scientific bodies and environmental education scholarship (e.g., Bhattacharya et al., 2020; Dillon &

**Table 1.** Summary of climate literacy competencies & congruent actions

CL competency	Associated knowledge & actions
(1) Show knowledge of climate systems & accurately apply this knowledge.	Develop a systems-thinking mentality, where climate changes are understood holistically by their impacted & impacting parts.
(2) Recognize causes & consequences of climate change.	Connect human activities, including their own, to climate change consequences such as biodiversity loss, resource scarcity, & worsening weather events.
(3) Identify inequitable aspects & disproportionate impacts of climate change.	Understand that certain communities & peoples are drastically impacted by climate change & need urgent action.
(4) Critically analyze claims & arguments presented in climate science discussions.	Demarcate between reliable climate news & information sources from misinformation & disinformation.
(5) Engage in meaningful personal & community actions to address climate change.	Uptake personal pro-climate actions like reduced energy use & advocate for climate-friendly policies in schools, businesses, & communities.

Herman, 2023; Leve et al., 2023; NOAA, n. d.; United Nations, n. d.; Wolf & Moser, 2011). Then, by synthesizing overlaps and frequently observed competencies across the definitions of CL, we synthesized a list of five fundamental aspects of a climate-literate person. While not exhaustive, our list offers a concise yet comprehensive description of CL. The five competencies are, as follows.

### Functional Knowledge of Climate Change Science & Systems

The first competency, climate knowledge, was consistently featured in all reviewed definitions and encompasses the essential scientific knowledge pertinent to understanding climate change (Bhattacharya et al., 2020; Cantell et al., 2019; Hornsey & Fielding, 2016). Strong evidence indicates that an individual's acceptance of climate change is intricately linked to their understanding of scientific ideas such as the carbon cycle and the nature of climate research (Leve et al., 2023; Monroe et al., 2017; NOAA, n. d.; United Nations, n. d.).

### Knowledge That Climate Change is Human-Induced

In addition to conceptual knowledge of climate systems, a second critical competency of CL is recognizing that humans and human activities significantly accelerate the changing climate (AAAS, 2014; United Nations, 2021). Understanding how our social, political, economic, and scientific advancements detrimentally impact local and global environments is a crucial initial step in envisioning and working toward sustainable societies.

### Knowledge That Climate Change Has Far-Reaching Consequences

In addition to conceptual knowledge, contemporary definitions of CL underscore a focus on the environmental, social, and justice implications of climate change. Research suggests that accepting climate change is significantly influenced by the ways that an individual perceives the risks to themselves, their communities, and other global communities (Hermans & Korhonen, 2017; Miléř, T., & Sládek, 2011; NOAA, n. d.). That is, if one does not feel that climate change will directly impact their immediate contexts, then it is unlikely that one will be willing to support mitigation efforts (Hornsey & Fielding, 2016; Kollmuss & Agyeman, 2010).

Recognizing the inequitable causes and consequences is particularly valuable for developing empathetic perspectives on the disproportionate impacts of the climate crisis (Heddy et al., 2021).

### Ability to Critically Assess Climate Change Claims & Media

The surge in digital misinformation, notably on contentious science topics such as climate change, has prompted educational responses to equip the public with the tools and competence to assess claims for credibility (Cook et al., 2017). The power of the internet to disseminate information, accurate or otherwise, poses a substantial hurdle to educating people about CL (Osborne & Pimentel, 2022). Therefore, it is imperative that the public can recognize and resist intentional efforts that discredit climate change experts.

### Ability to Take Meaningful Actions Against Climate Change

Consistent across definitions, the fifth competency calls for people to adopt pro-environmental climate actions (Sinatra et al., 2011; Wolf & Moser, 2011). Unlike the preceding knowledge-focused competencies, this fifth competency underscores the importance of skills and capabilities in making decisions that reduce individual contributions to the changing climate (Brinkmann, 2021). These actions, spanning personal, community, and global levels, play a pivotal role in the collective efforts to mitigate the consequences of climate change (Salvador Costa et al., 2021; Wynes & Nicholas, 2017). **Table 1** summarizes these competencies and associated real-world actions.

Together, the five competencies embody the essential knowledge and capabilities requisite for a person to engage with climate change solutions. Education that is committed to CL prioritizes integrating all five as core student learning outcomes. This means going beyond climate science knowledge to engage students with the social, economic, ethical, and participatory aspects of addressing climate change (Kenis & Mathijs, 2012).

Unfortunately, climate education initiatives have struggled to achieve a significantly climate-literate general public. Yale Climate Opinion Maps indicate that only 72% of US adults believe in global warming, and just 57% attribute it to human activities (Howe et al., 2015; Milfont et al., 2021). While acceptance is slowly growing, scholars have not observed tangible shifts in the planet's health and climate trajectory. Greenhouse gas emissions continue to rise annually, and alternative energy adoption is limited, often impeded by political resistance (Borenstein, 2022; Murphy, 2021; Rowlett, 2023). Furthermore, acceptance of climate change is strongly linked to pro-climate engagement and actions needed to drive societal changes (Dillon & Herman, 2023).

Thus, there is a disparity between the aspirations we have for CL and what occurs in the real world. We contend that the responsibility to bridge this gap lies with a re-envision approach to climate education. Presently, the integration of CL into classrooms is often inadequate and lacks a clear vision of what students should learn and experience. We argue that this deficiency is the result of an overemphasis on knowledge-based outcomes at the expense of outcomes focused on proactive personal habits and commitments to the environment. Following sections substantiate our argument and present a revised vision of climate education that balances the essential competencies of a climate-literate public.

## TODAY'S CLIMATE EDUCATION CHALLENGE

The competencies of CL include both knowledge and action. The first four represent essential knowledge domains for informed participation in conversation, political processes, and media. Well-designed instruction can enhance students' understanding of climate science, the nature of science, and the sociocultural facets of changing climates (Cantell et al., 2019; Cook et al., 2017; Hornsey et al., 2016). Successful learning interventions and approaches have led to extensive efforts to integrate climate change education into school curricula. Notably, the next generation science standards, a widely adopted the US K-12 education framework, explicitly addresses aspects of climate change science such as atmospheric composition, carbon cycles, and human-environmental relations (Next Generation Science Standards Lead States [NGSS], 2013). This inclusion into mandatory science curricula highlights the growing importance of climate education to educational policymakers.

The fifth competency is distinct from the other four because it focuses on the behaviors and actions that people can take to address climate change positively. Instead of simply recognizing and understanding the scientific, social, economic, and environmental aspects of climate change, the fifth competency implicates climate-literate people as responsible agents of change. These people actively take measures to reduce their impact on the environment, such as reducing their energy consumption and supporting environmentally-friendly policies and initiatives. However, education that develops the motivation and capacity to act is often not intuitive and influenced by a multitude of factors and barriers (Kollmuss & Agyeman, 2010). Learning how to take pro-climate actions requires practice, experience, and reflection, all of which are rarely integrated into school learning. Moreover, choosing to engage in pro-climate actions is often inhibited by ideological worldviews, personal values and norms, mistrust of politicians and climate experts, and perceived costs (Gifford, 2011). Collectively, the fifth competency of CL requires an education that can navigate these impediments and provide students with authentic learning experiences.

There are many examples of successful climate education initiatives that have resulted in incredible and desirable outcomes. Instances of student-led demonstrations, advocacy for pro-climate businesses, and grassroots social media

campaigns underscore the transformative impact education can have on students and the broader climate crisis. One prominent example is Greta Thunberg's rise as the voice of millions of climate-concerned students around the world (Kraemer, 2024). Greta's message, stressed by her famous statement "How dare you," has inspired hundreds of student-led climate protests across the globe and reimagined the discourse on what education can accomplish. Greta and others have challenged the traditional paradigms of education and called for efforts that support students' knowledge, capabilities, and passions for a sustainable future and climate-conscious communities (Cordero et al., 2020; Geiger et al., 2017; Hess & Maki, 2019; Monroe et al., 2017; Sinatra et al., 2011).

We draw attention to the research and notable outcomes to show the powerful role that climate education can play in progressing our planet toward a sustainable future. This future requires people who are components of both knowledge and action. As science education scholar Windschitl (2023) puts it:

"Education plays a central role in cultural transformations, not just one child at a time, but developing 'just enough' social influence to facilitate action" (p. 10).

Unfortunately, the majority of the US climate education is geared toward the recollection of scientific facts, not sociocultural considerations or empowering students to action (Dillon & Herman, 2023). This oversight is regrettable, given the evidence showing that education can successfully motivate students for concern and engagement.

## CLIMATE LITERACY: WHAT NEEDS TO CHANGE?

The evidence is clear that education plays a significant role in advancing efforts to address climate change. However, the majority of the US students do not receive a comprehensive climate education (Dillon & Herman, 2023). Specifically, required education standards often neglect the social, political, and ethical dimensions of climate change (McCaffrey & Buhr, 2008; Wibeck, 2013). Also, opportunities for students to engage in authentic decision-making and action are rare (Hufnagel et al., 2017). Since knowledge objectives are prioritized over experiences, students are underprepared to assume civic roles and responsibilities in a rapidly changing world (McCaffrey & Buhr, 2008; Zummo et al., 2020).

Several factors influence the unequal emphasis on knowledge over action. These include insufficient teacher preparation, standardized testing focused on knowledge recall, and politically motivated education policies (Dillon & Herman, 2023). However, these factors stem from a more fundamental issue concerning the ways that climate education purposes are conceptualized. Prominent calls for CL lack precise outlines for the expectations of a climate-literate public, leading to ambiguity and an inability to structure teaching in a manner that addresses all five competencies. An examination of the literature results in two major critiques that substantiate our issue with CL:

### 1. A disconnect between climate knowledge and practice:

One shortcoming of contemporary climate education is a lack of explicit connections to personal and community-level civic responsibility. That is, students rarely have opportunities in the classroom to apply their scientific and civic knowledge to meaningful social issues they care about (Dillon & Herman, 2023). For instance, a government class often educates students about how bills become official policies with the help of a local community representative. Such a lesson is the perfect opportunity to address why climate bills often get stalled and what people can do to advocate for such bills to become enacted policies. This is not intuitive, and without explicit instruction and opportunities to practice communicating with elected officials, students will rarely connect class topics with their own interests and capacity to act. Without the educator making this connection overt, the knowledge regarding how policies are developed is likely to lose meaning and value for learners.

### 2. Compartmentalization of climate education:

A second shortcoming is the confinement of climate education to the science classroom despite its wealth of interdisciplinary topics. Unfortunately, climate change is compartmentalized within the earth and physical science classrooms (Strauss, 2021). Like many social science issues (e.g., vaccines, nuclear energy, antibiotics), climate change possesses many intricacies that can enrich civics, economics, literature, and technology classrooms in addition to science. Unfortunately, the interdisciplinary nature of climate change is rarely made overt to students during their school experience. Different disciplines' perspectives and instruction are often not embedded with climate change-related ideas, readings, and media. By confining climate change topics to the science classroom, valuable opportunities to explore different ways of engaging with climate change are overlooked.

The five CL competencies are an excellent framework for the goals of climate education. However, given the constraints, critiques, and limited success in the US CL, we advocate for a profound rebalancing of the desired purposes and outcomes of climate education.

In recognition of the challenges for formal climate education—such as resource constraints, time limitations, competing curricula, and mandatory assessments—we propose a reframed vision, which we term *climate agency*. The notion of *agency* shifts the primary objective of the 'informed public' to the 'empowered public.' It poses an essential question for educators: *What knowledge and capabilities do people need to change the planet's future?*

Educators and institutions who thoughtfully reflect on this question and care for the empowerment of people will recognize that the field of climate education needs a clearly defined purpose. That purpose needs to reach classrooms and students everywhere. Present education efforts must be designed with agency, not literacy, in mind.

## ADVOCATING FOR CLIMATE AGENCY

There are serious reasons to be concerned about the future of our planet. However, ample time and energy remain to mitigate the most severe impacts (NASA, 2019). Around the world, numerous motivated and capable young people, including educators, are eager to address climate change (Moser & Dilling, 2007). We must do our best to guide and harness this passion, empowering students with the agency to alter the trajectory of our planet.

Agency refers to the feeling of efficacy that one has both the knowledge and abilities to take actions that achieve meaningful results. Education striving towards agency incorporates knowledge-centered instruction, i.e., the "whats" and "whys" of climate change, but it also emphasizes the "hows" (Tolppanen & Aksela, 2018). Educators who can effectively facilitate both knowledge and action in their contexts will better prepare students to take perspectives and reasoned decisions to critical climate questions such as:

- *How does leaving the lights on increase your carbon footprint?*
- *How can reducing your food waste help reduce greenhouse gas emissions?*
- *What are some ways to identify and contribute towards improving community environmental challenges?*
- *How can you address climate misinformation while conversing with skeptics, especially those who are close to you?*
- *What are some ways you can participate in or start community environmental groups?*
- *What are some effective ways to communicate environmental concerns to your local elected officials?*
- *Whose carbon contributions and impacts are the greatest? How can we be advocates for diminishing these impacts?*

Educators and education institutions should make every effort to model instruction and learning that reflects the sustainable world often envisioned. This requires substantial efforts from all vested stakeholders, including those who designed the required curricula, those who support policy and funding for formal education, and those who lead students in learning every day. Such efforts are grand but achievable. We report the following two real-world examples of what an interdisciplinary and holistic education for climate agency can be:

### 1. Native American students engage with complexities of water shortages:

In 2017, a first-year earth science teacher wanted to address the water shortage issues at his rural high school nestled within the lands of the Colorado River Indian Tribe. Passionate about environmental science and the water issues facing his new community, the teacher engaged students in a series of lessons and content addressing key water science ideas, various water rights stakeholder perspectives, and ethical dilemmas regarding natural resources. The lesson sequence culminated with student participation in a community-level service-learning project about raising awareness and starting dialogue centered around climate-induced

drought. Groups of students created posters that were displayed around the school district and town public spaces. The posters drew attention to the decreasing Colorado River, the consequences of the water shortage, and ways the community could adopt to conserve water. While not explicitly advocating for community water needs to the state government, the project prompted valuable social conversations within students' families, elevating their voices and enhancing community awareness of the water issue.

2. **Utah students protest for climate-oriented school curriculum:** In 2022, amid the global climate strikes, a group of high school students just outside Salt Lake City expressed major concerns about how climate change was taught in their school. At the time, Utah State science standards addressed climate aspects such as global weather and climate patterns. The students wanted the state curriculum to give more attention to the ways humans interact with and alter the climate. The students collaborated with a supportive teacher and organized a climate protest at the Utah State capitol building. The protest included delivering letters urging a curriculum overhaul to address present and future climate challenges. One of the student leaders shared a comment with the local news that captured the students' message:

"We must have education for our future. We need to have education on how to live more sustainably and how to deal with the problems we see in our future" (Williams, 2022).

We highlight these examples to show that there is a body of students who are passionate and capable of tackling climate change. However, it is unlikely that we can harness this force without our classroom educators, policymakers, and greater community leading the way.

## CONCLUSIONS

There is an urgent need for well-designed and purposeful climate education to become an integral component of students' school experiences. While many calls have been issued for CL, we find that the implementation of CL is insufficient and unbalanced, resulting in a public that does not feel empowered to act. Climate change education is interdisciplinary, and concerted efforts across school subjects can provide students with meaningful learning opportunities. Moreover, by reconceptualizing literacy to agency, we can shift the purpose of climate change education from an informed public to one that is empowered. This means that those involved in education, whether policy makers, administrators, educators, or the public, should demand that interdisciplinary climate change education become an integral part of a student's K-12 experience. This requires everyone to embrace the challenge of integrating both climate knowledge and responsible action into the school experience. In the end, educators have the responsibility and honor of shaping our future public and planet

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## REFERENCES

- AAAS. (2014). What we know: The reality, risks, and response to climate change. *American Association for the Advancement of Science*. <https://whatwewknow.aaas.org/get-the-facts/>
- Bhattacharya, D., Carroll Steward, K., & Forbes, C. T. (2020). Empirical research on K-16 climate education: A systematic review of the literature. *Journal of Geoscience Education*, 69(3), 223-247. <https://doi.org/10.1080/10899995.2020.1838848>
- Borenstein, S. (2022). Carbon dioxide emissions rising globally but drop in China. *Associated Press*. <https://apnews.com/article/science-africa-china-egypt-united-states-aaa101485a0236f818952bf90360ccf3>
- Brinkmann, R. (2021). *Practical sustainability: A guide to a more sustainable life*. Springer. <https://doi.org/10.1007/978-3-030-73782-5>
- Cantell, H., Tolppanen, S., Aarnio-Linnanvuori, E., & Lehtonen, A. (2019). Bicycle model on climate change education: Presenting and evaluating a model. *Environmental Education Research*, 25(5), 717-731. <https://doi.org/10.1080/13504622.2019.1570487>
- Cook, J., Lewandowsky, S., & Ecker, U. K. (2017). Neutralizing misinformation through inoculation: Exposing misleading argumentation techniques reduces their influence. *PLoS ONE*, 12(5), e0175799. <https://doi.org/10.1371/journal.pone.0175799>
- Cordero, E. C., Centeno, D., & Todd, A. M. (2020). The role of climate change education on individual lifetime carbon emissions. *PLoS ONE*, 15(2), e0206266. <https://doi.org/10.1371/journal.pone.0206266>
- Dillon, J., & Herman, B. C. (2023). Environmental education. In L. Zeidler, N. G. Lederman, & J. S. Lederman (Eds.), *Handbook of research on science education: Volume III* (pp. 717-740). Routledge.
- Geiger, N., Swim, J. K., & Fraser, J. (2017). Creating a climate for change: Interventions, efficacy and public discussion about climate change. *Journal of Environmental Psychology*, 51, 104-116. <https://doi.org/10.1016/j.jenvp.2017.03.010>
- Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, 66(4), 290-302. <https://doi.org/10.1037/a0023566>

- Heddy, B. C., Lombardi, D., & Danielson, R. W. (2021). The moral side of the climate crisis: The effect of moral conviction on learning about climate change. *Educational and Developmental Psychologist, 39*(1), 58-69. <https://doi.org/10.1080/20590776.2021.2011203>
- Hermans, M., & Korhonen, J. (2017). Ninth graders and climate change: Attitudes towards consequences, views on mitigation, and predictors of willingness to act. *International Research in Geographical and Environmental Education, 26*(3), 223-239. <https://doi.org/10.1080/10382046.2017.1330035>
- Hess, D. J., & Maki, A. (2019). Climate change belief, sustainability education, and political values: Assessing the need for higher-education curriculum reform. *Journal of Cleaner Production, 228*, 1157-1166. <https://doi.org/10.1016/j.jclepro.2019.04.291>
- Hornsey, M. J., Harris, E. A., Bain, P. G., & Fielding, K. S. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nature Climate Change, 6*(6), 622-626. <https://doi.org/10.1038/nclimate2943>
- Howe, P. D., Mildenerger, M., Marlon, J. R., & Leiserowitz, A. (2015). Geographic variation in opinions on climate change at state and local scales in the USA. *Nature Climate Change, 5*(6), 596-603. <https://doi.org/10.1038/nclimate2583>
- Hufnagel, E., Kelly, G. J., & Henderson, J. A. (2017). How the environment is positioned in the next generation science standards: A critical discourse analysis. *Environmental Education Research, 24*(5), 731-753. <https://doi.org/10.1080/13504622.2017.1334876>
- João, M., Leitão, A., Rosa Maria Silva, Monteiro, V., & Melo, P. (2022). Climate change prevention through community actions and empowerment: A scoping review. *International Journal of Environmental Research and Public Health, 19*(22), 14645-14645. <https://doi.org/10.3390/ijerph192214645>
- Kenis, A., & Mathijs, E. (2012). Beyond individual behaviour change: The role of power, knowledge and strategy in tackling climate change. *Environmental Education Research, 18*(1), 45-65. <https://doi.org/10.1080/13504622.2011.576315>
- Kollmuss, A., & Agyeman, J. (2010). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239-260. <https://doi.org/10.1080/13504620220145401>
- Kraemer, D. (2024). Greta thunberg: Who is the climate campaigner and what are her aims? *BBC News*. <https://www.bbc.com/news/world-europe-49918719>
- Leve, A.-K., Michel, H., & Harms, U. (2023). Implementing climate literacy in schools—What to teach our teachers? *Climatic Change, 176*, 134. <https://doi.org/10.1007/s10584-023-03607-z>
- McCaffrey, M. S., & Buhr, S. M. (2008). Clarifying climate confusion: Addressing systemic holes, cognitive gaps, and misconceptions through climate literacy. *Physical Geography, 29*(6), 512-528. <https://doi.org/10.2747/0272-3646.29.6.512>
- Milěř, T., & Sládek, P. (2011). The climate literacy challenge. *Procedia-Social and Behavioral Sciences, 12*, 150-156. <https://doi.org/10.1016/j.sbspro.2011.02.021>
- Milfont, T. L., Zubielevitch, E., Milojević, P., & Sibley, C. G. (2021). Ten-year panel data confirm generation gap, but climate beliefs increase at similar rates across ages. *Nature Communications, 12*, 4038. <https://doi.org/10.1038/s41467-021-24245-y>
- Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2017). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research, 25*(6), 791-812. <https://doi.org/10.1080/13504622.2017.1360842>
- Moser, S. C., & Dilling, L. (2007). *Toward the social tipping point: Creating a climate for change*. Cambridge University Press. <https://doi.org/10.1017/cbo9780511535871.035>
- Murphy, S. P. (2021). Climate change and political (in)action: An intergenerational epistemic divide? *Sustainable Environment, 7*(1), 1951509. <https://doi.org/10.1080/27658511.2021.1951509>
- NASA. (2019). Is it too late to prevent climate change?—Climate change: Vital signs of the planet. NASA. <https://climate.nasa.gov/faq/16/is-it-too-late-to-prevent-climate-change/>
- NGSS. (2013). *Next generation science standards: For states, by states*. The National Academies Press.
- NOAA. (n. d.). The essential principles of climate literacy. *Climate.gov*. <https://www.climate.gov/teaching/climate>
- Osborne, J., & Pimentel, D. (2022). Science, misinformation, and the role of education. *Science, 378*(6617), 246-248. <https://doi.org/10.1126/science.abq8093>
- Owens, D. C., Sadler, T. D., & Friedrichsen, P. (2019). Teaching practices for enactment of socio-scientific issues instruction: An instrumental case study of an experienced biology teacher. *Research in Science Education, 51*, 375-398. <https://doi.org/10.1007/s11165-018-9799-3>
- Rowlatt, J. (2023). Fossil fuels: Can humanity really kick its addiction? *BBC News*. <https://www.bbc.com/news/science-environment-67661119>
- Salvador Costa, M. J., Leitão, A., Silva, R., Monteiro, V., & Melo, P. (2022). Climate change prevention through community actions and empowerment: A scoping review. *International journal of environmental research and public health, 19*(22), 14645. <https://doi.org/10.3390/ijerph192214645>
- Sinatra, G. M., Kardash, C. M., Taasobshirazi, G., & Lombardi, D. (2011). Promoting attitude change and expressed willingness to take action toward climate change in college students. *Instructional Science, 40*, 1-17. <https://doi.org/10.1007/s11251-011-9166-5>
- Strauss, V. (2021). Why it's a mistake to teach climate change only in science class. *Washington Post*. <https://www.washingtonpost.com/education/2021/09/22/how-teach-climate-change-crisis/>

- Tolppanen, S., & Aksela, M. (2018). Identifying and addressing students' questions on climate change. *The Journal of Environmental Education*, 49(5), 375-389. <https://doi.org/10.1080/00958964.2017.1417816>
- United Nations. (2021). Climate change "biggest threat modern humans have ever faced," world-renowned naturalist tells security council, calls for greater global cooperation. *United Nations*. <https://press.un.org/en/2021/sc14445.doc.htm>
- United Nations. (n. d.). Teaching carbon literacy to combat climate change. *United Nations*. <https://www.un.org/en/academic-impact/teaching-carbon-literacy-combat-climate-change>
- US EPA. (2023). Overview of greenhouse gases. *United States Environmental Protection Agency*. <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>
- Wibeck, V. (2013). Enhancing learning, communication and public engagement about climate change—Some lessons from recent literature. *Environmental Education Research*, 20(3), 387-411. <https://doi.org/10.1080/13504622.2013.812720>
- Williams, C. (2022). Why these students want Utah to make a change to climate education. *www.ksl.com*. <https://www.ksl.com/article/50375266/why-these-students-want-utah-to-make-a-change-to-climate-education>
- Windschitl, M. (2023). *Teaching climate change: Fostering understanding, resilience, and a commitment to justice*. Harvard Education Press.
- Wolf, J., & Moser, S. C. (2011). Individual understandings, perceptions, and engagement with climate change: Insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change*, 2(4), 547-569. <https://doi.org/10.1002/wcc.120>
- World Economic Forum. (2022). The chairperson's guide to climate. *World Economic Forum*. [https://www3.weforum.org/docs/WEF\\_CoC\\_TheChairpersonsGuidetoClimate\\_April2022.pdf](https://www3.weforum.org/docs/WEF_CoC_TheChairpersonsGuidetoClimate_April2022.pdf)
- Wynes, S., & Nicholas, K. A. (2017). The climate mitigation gap: Education and government recommendations miss the most effective individual actions. *Environmental Research Letters*, 12(7), 074024. <https://doi.org/10.1088/1748-9326/aa7541>
- Zummo, L., Donovan, B., & Busch, K. C. (2020). Complex influences of mechanistic knowledge, worldview, and quantitative reasoning on climate change discourse: Evidence for ideologically motivated reasoning among youth. *Journal of Research in Science Teaching*, 58(1), 95-127. <https://doi.org/10.1002/tea.21648>