INNOVATIONS IN SCIENCE TEACHER EDUCATION
AN ASTE JOURNAL
VOL. 11, NO. 3

Learning about Climate Justice Education through Curriculum Analysis

Heather F. Clark
California State University, Dominguez Hills

Megan Sulsberger
California State University, Monterey Bay

ABSTRACT
The purpose of this article is to advance climate justice education in teacher preparation programs. The article presents educational curriculum resources and pedagogical practices for integrating climate justice education in pre-service elementary teacher courses. The resources include a model unit designed as educative curriculum material, along with companion guides for pre-service teachers and teacher educators. The pedagogical practices center on curriculum analysis of the model unit, designed to support pre-service teachers in learning both the rationale for and pedagogies of climate justice education. The model unit, *Watching Over Water in Times of Changing Climate*, is based on 2nd-grade interdisciplinary standards that investigate issues of water and climate justice at the regional and local levels. This paper shares a menu of options for integrating the model unit in elementary science methods courses, including practical activities and reflective discussion or writing prompts. In addition, we present case studies and empirical evidence from the implementation of the resources and practices, including thematic analysis of pre-service teachers' responses to reflective prompts. These resources and practices address a persistent gap in teacher preparation programs, specifically the disconnect between stated commitments to climate justice and the limited pedagogical tools available to enact those commitments.

Keywords: Climate Justice Education; Climate Justice Pedagogy; Elementary Science Education; Teacher Preparation Programs; Educative Curriculum Materials; Curriculum Analysis

Opportunity Spaces for Climate Justice Pedagogy in Teacher Preparation

Climate justice education is an emerging pedagogical approach that positions classrooms as sites of socioecological transformation and teachers as agents of socioecological justice (Sover & Walsh, 2022). We are at a moment when there is a broad consensus that education can, should, and must be a driving force in building societal awareness and changing societal structures that cause the climate crisis. Yet the pedagogical practices to do that work are not widely known or accessible. This gap reflects a disconnect between the hearts and minds of teachers and teacher educators– our hearts want to be part of the solution to the crisis, but our minds do not know what professional actions to take.

We aim to narrow this gap between hearts and minds through our work in teacher preparation programs (TPPs). As professors of science teacher education, we see opportunity

spaces for closing this gap in our elementary science methods courses. Specifically, we identify the practice of curriculum analysis as an opportunity space that facilitates pre-service teachers (PSTs) in the reflective and critical analysis of curriculum as part of their professional learning and preparation. Curriculum analysis is a practice widely used in TPPs, as it supports PSTs in learning to make thoughtful judgments in the classroom, specifically by developing their professional judgment and professional identity (Bocala & Boudreault, 2020; Brown et al., 2020). Through this practice, PSTs learn that curriculum is never neutral and that teachers must see themselves not only as users, but also as designers of curriculum that critically examine what is included and excluded, for what purposes, and with what consequences before making informed decisions about adaptation and enactment (Sleeter, 2017).

In this article, we present the rationale, resources, and empirical findings from our approach to integrating climate justice education in PST education. We see this opportunity space existing for two primary reasons that we address with the resources in this article. First, part of the gap between hearts and minds is due to climate justice education being emergent and amorphous, and therefore, resources that represent research-based practices are scarce or inaccessible. The model unit we share here is designed as an object of inquiry for PSTs to explore through curriculum analysis with the goal of learning about climate justice education.

Second, teacher educators are primarily tasked with preparing PSTs to enhance their skills and knowledge for teaching across disciplines (Cochran-Smith, 2003; Cochran-Smith et al., 2018). We are not tasked with addressing any particular social issue, such as the climate crisis, but rather to prepare teachers for the profession in general. However, as Alexander (2023) argues in his framework for thinking about the next 80 years of education, climate change will transform every aspect of life, including what we teach and research at universities. We want to proactively transform our practices now rather than reactively in the future. Current teacher preparation in climate change education falls short of equipping teachers to make education a driver of social transformation toward a just and sustainable future. The resources and practices presented in this article are designed to support teacher educators and PSTs to be part of the solution to climate change through their professional practice.

Guided by this framing, the purpose of this work is to examine how curriculum analysis can function as a pedagogical lever for climate justice education in elementary science teacher preparation. Using a self-study approach (Berry & Kitchen, 2020), we answer the following question: How was curriculum analysis of a model unit implemented in elementary science methods courses to advance teacher preparation for climate justice education? This question foregrounds PST learning through curriculum analysis and examines how climate justice education can be integrated into existing structures of elementary teacher preparation. To complement the presentation of our experiences teaching with the model curriculum, we analyze PSTs' written reflections about their learning experience.

Climate Justice Education and Pedagogy

Climate justice education is an emerging pedagogical response to the urgency and inequities of the climate crisis. To counter sanitized, apolitical approaches to climate change

education that ignore issues of race, power, and culture, climate justice education situates climate change in emotional, ethical, social, and cultural contexts (Sover & Walsh, 2022). As a form of social justice education, climate justice education invites students to consider how the impacts of climate change differ across racial, socioeconomic, geographic, and intergenerational lines (Borgerding et al., 2023). In doing so, climate justice education positions students not only as learners of scientific concepts but as critical thinkers and ethical actors within complex socioecological systems (Gallay et al., 2021; Gallay et al., 2022).

A central goal of climate justice education is the development of climate justice literacy. Our conceptualization of this literacy is grounded in our work with the Environmental and Climate Change Literacy Projects (ECCLPs), a research–practice partnership formed in 2018 across the University of California and California State University systems (Lee et al., 2025; ECCLPs, nd). A climate-literate student thinks holistically with a justice orientation. This includes understanding the scientific basis of climate change and using this understanding to investigate connections between climate, social systems, and power structures that drive disparities that create climate injustices for different demographics (Benevolenza & DeRigne, 2019; Hickel, 2020). Next, a climate-literate student understands impacts and solutions from local to global scales (Foley et al., 2020). This includes valuing Indigenous knowledge as a model for sustainable human-nature relationships. Additionally, a climate-literate student recognizes their own agency to effect change, such as taking ownership of their influence on climate change and the impact of collective action and activism (c.f. Garcia et al., 2020).

For students to develop this literacy, their teachers need to understand climate justice education and develop climate justice pedagogies. For PSTs in science methods courses, this understanding begins with seeing how each of the three aspects of climate justice literacy can be introduced and developed with their future students. This requires TPPs to move beyond content-focused instruction and toward pedagogical approaches that integrate scientific understanding with critical analysis, ethical reasoning, and action-oriented learning. In this way, climate justice education depends not only on what teachers teach about climate change, but how they engage students in making sense of climate change issues as matters of justice, responsibility, and possibility. In the sections below, we explore how our approach supports PSTs in seeing how they can support justice-oriented, solution-oriented, and agency-oriented classroom activities for climate justice education.

Watching Over Water in Times of Changing Climate **Model Unit**

We worked for 15 months to collaboratively design the model unit (which we will abbreviate as *Watching Over Water* here) with eight other members of ECCLPs. The unit is open-source and includes 2nd-grade science, literacy, and history-social studies concepts through the lens of climate justice (find the unit in the Supplemental Material or online at https://tinyurl.com/WatchingOverWater). Figure 1 summarizes the unit that explores the regional anchoring phenomenon of dam removal on the Klamath River, then moves to a local investigable phenomenon of water justice issues. The unit launches with a Cordel activity (Fletcher & Holyoke, 2025) about the Klamath River and ends with students creating a Public Service Announcement advocating for water justice in their community. The sequence of 14

lessons illustrates justice-oriented, solution-oriented, and agency-oriented learning about climate change. The unit is designed to support inquiry about how climate, water, and social systems interact to create the disrupted socioecological systems of today and explore opportunities for collective rejuvenation of systems and relationships in the future. This unit was not designed to be ready-to-teach, but rather as an object of inquiry for PSTs in TPPs.

Figure 1

Watching Over Water in Times of Changing Climate Storyline

Examining Rivers *What can change the shape and health of a river over time?*	**Exploring Water Sources in my Community** *What water near our home do we want to watch over?*	**Tracing Water Sources in My Community** *How can we predict helpful ways to watch over water?*	**Taking Action** *What activities can I help with to watch over water near our home?*
Lesson 1: Cordel: What do we know about water watchers and the Klamath River? What do we wonder about water watchers and the Klamath River? **Lesson 2:** Who/which groups have influenced the shape and health of the Klamath River? **Lesson 3:** What words and symbols can we use to best convey our ideas about water watching? **Lesson 4:** What can change the shape of a rivers? **Lesson 5:** How and why has the shape of the Klamath River changed over time?	**Lesson 6:** Where are bodies of water in my community? **Lesson 7:** What can change the shape of a rivers in my community? **Lesson 8:** What water in our community do we want to watch over? What wonderings do we have?	**Lesson 9:** How can we predict helpful ways to watch over water? How are water and climate systems interconnected? **Lesson 10:** How can we use data visualizations to understand and share changes in local rivers? **Lesson 11:** How can we watch over water? **Lesson 12:** Who is someone who has watched over the Klamath River? **Lesson 13:** What activities can I help with to watch over water in my community? How can we predict helpful ways to watch over water?	**Lesson 14:** Culminating task: Create a Public Service Announcement: How can we watch over water?

Teacher learning theory suggests that teachers and curriculum materials interact in a dynamic, collaborative, participatory relationship in which teachers actively draw on their experiences, beliefs, knowledge, and goals, and these personal resources shape how teachers enact curriculum in practice (Brown, 2009; Remillard, 2005). Based on this understanding, we

designed the *Watching Over Water* model unit as educative curriculum material to support teacher learning. Davis and Krajick (2005) define educative curriculum material as specifically and intentionally designed to support the learning of teachers. Educative curriculum material has been used to support teacher learning for several decades and is a powerful tool to support teacher and student learning (Davis et al., 2017). These material often includes teachers' guides, which are "designed to offer information, instructions, and suggestions that will aid in the construction of curriculum" and "are meant to guide action and decision making" (Remillard, 2018, p. 263). We build on work that utilizes educative curriculum materials to support PST learning (Beyer & Davis, 2009; Donna & Hick, 2017).

Curriculum Analysis Practices in Elementary Science Methods

In this section, we describe four practices, or instructional strategies, of curriculum analysis that can be used to support PSTs' reflection on the *Watching Over Water* unit in elementary science methods courses. The practices are intended to be used with an annotated companion guide that accompanies the model unit (find the guide in the Supplemental Material or online at https://tinyurl.com/WatchingOverWater). These practices are meant to develop PSTs' understanding of climate justice education (what concepts can be taught), climate justice pedagogy (how those concepts can be taught), and climate justice integration with subject matter-specific instruction.

Pre-thinking

Before engaging with the model unit, PSTs are invited to engage in pre-thinking activities that uncover their beliefs, assumptions, and questions about climate change, climate justice, and elementary science instruction. Pre-thinking prompts may include reflective writing, small-group discussion, or structured think–pair–share activities focused on questions such as: What does climate justice mean to you? What experiences, if any, have you had teaching or learning about climate change? What concerns or uncertainties do you have about addressing justice-oriented issues in elementary classrooms? This practice supports PSTs in making their prior thinking visible and creates an entry point for examining how their perspectives may shift through curriculum analysis. Pre-thinking also establishes a reflective stance that positions PSTs as learners whose ideas are expected to evolve through engagement with curriculum materials.

Analytical Lens

PSTs may also be asked to apply an analytical lens through which to examine the model unit. Teacher educators can select any number of analytical lenses that are justice-oriented, solution-oriented, or agency-oriented, and can be aligned with diverse goals. For example, PSTs may analyze the curriculum using a place-based pedagogy lens, attending to how place is represented, whose knowledge is centered, and how local contexts are positioned as educational assets. From this perspective, PSTs work to identify dimensions of place and associated affordances in the *Watching Over Water* unit. Using a focused analytical lens supports PSTs in moving beyond surface-level evaluation of activities and toward intentional analysis of how pedagogical commitments are enacted through curriculum design.

Adult Learner Experiences

Another curriculum analysis practice involves engaging PSTs in selected learning activities from the model unit as adult learners (Fantacone, 2024). This practice is widely used in science teacher education to support learning about Science and Engineering Practices by positioning PSTs as learners before asking them to teach those practices (Salter & Atkins, 2013; Watkins et al., 2023). For example, PSTs can create and revise predictive scientific models of a local river and explain how a justice-oriented action would be restorative to local water and climate. Engaging in these activities as a learner rather than as a teacher allows PSTs to reflect on the cognitive, emotional, and social dimensions of learning, and to consider how instructional moves support or constrain engagement.

"Pause to Ponder" and "Pause to Plan" Reflective Questions

Included in the companion guide are questions that teacher educators can use with PSTs to help them reflect on how the specific tasks and activities in the *Watching Over Water* unit contribute to elementary students' learning and skill development. Organized as opportunities to "ponder" and "plan," the prompts fall into various categories designed to be both reflective and action-oriented, encouraging PSTs to bridge educational theory with hands-on classroom practice. The "ponder" prompts can help PSTs analyze instructional choices, anticipate student engagement, and explore how they might adapt or extend these lessons to create meaningful learning experiences. The "plan" prompts are designed to help PSTs translate their reflections into concrete, actionable teaching strategies.

Case Studies of Implementation

In this section, we summarize how we piloted the model unit in our elementary science methods courses. These summaries are based on self-study of our practices as teacher educators, which is a form of practitioner inquiry that "aims to understand situated human activity from the perspectives of those engaged in it" (Berry & Kitchen, 2020, p. 1). We also include thematic analysis of PSTs' response to the "pause and ponder" questions from Heather's course (Braun & Clarke, 2012). Grounded in the constant-comparative approach, we open-coded the data (n = 30 PSTs) by reading, re-reading, and coding to examine and share themes in PSTs' experiences (Glaser & Strauss, 1967).

Case 1: Heather's methods course

The first case comes from Heather who teaches a 3-unit elementary science methods course for multiple subject candidates. The course is PSTs' first introduction to the Next Generation Science Standards (NGSS), specifically the idea of learning science concepts through scientific practices. Heather's course and campus are deeply committed to educational equity therefore the course aims to help PSTs close the opportunity gap for learners traditionally marginalized in science education.

Heather integrated the model unit through a sequence of activities spread over the semester, representing 60-90 minutes of activity during seven different class sessions. Here I

will highlight three activities and associated challenges. First, I facilitated the Cordel activity from *Watching Over Water,* combined with an interactive reading aloud of Carole Lindstrom's "Autumn Peltier, Water Warrior" and "We are Water Protectors." The Cordel included photos from a) illustrations from the two books, b) photos from Standing Rock Protests of the Dakota Access Pipeline, c) photos, maps, and media from the Klamath River dam removal, and d) photos, maps, and media from local waterways. PSTs were guided to look for connections between the artifacts, and between the artifacts and their own experiences, and then to reflect on their experience in this activity and the potential experiences of 2nd-grade students. This activity highlights the transdisciplinary, intersectional nature of climate justice education for PST by illustrating ways to foreground justice dimensions and rejuvenating actions driven by youth. PSTs described this activity as rewarding and accessible, specifically because they could imagine combining science and English-Language Arts instruction through the thoughtful selection of children's literature.

Next, over a series of three class sessions, I facilitated adult learning experiences of scientific modeling. First, PSTs developed a consensus model of change of the Klamath River, and then, in small groups, PSTs developed an initial and revised model of change in local waterways (using the modeling template provided in *Watching Over Water*). The adult learner activity focused on helping PSTs develop a foundational understanding of the Science and Engineering Practice of developing and using models while also learning concepts about water and climate justice. These activities were challenging for PSTs since they did not experience NGSS-aligned teaching as students, nor did they have confidence in their own understanding of science concepts. Therefore, they expressed being overwhelmed by both the concepts and the practice. I found that the climate justice education component was layered onto this complexity and confusion and may have been pushed to the background by some PSTs. In the future, I hope to have activities focused on the scientific practice of modeling with simpler topics before moving to models of complex socioecological issues.

The third activity, spread throughout the semester, was working individually and in small groups to respond to the "pause to ponder "and "pause to plan" reflective questions. Structured as think-pair-shares, individual exit tickets, and small-group discussion prompts at different times, PST explored curriculum as a tool for accomplishing their teaching goals, reflected on power structures in schooling and society, and identified pedagogies and possibilities of climate justice education. I found that PSTs had the most thoughtful responses and the highest engagement when the reflective questions were tightly linked to the class's focus. For example, if we were exploring how to link science instruction to students' interests and assets, the PSTs excelled at identifying how *Watching Over Water* connected to children's everyday experiences. The questions were more challenging on days without that close alignment; therefore, in future years, I aim to link curriculum analysis of *Watching Over Water* more closely with the other activities in my course.

Table 1 presents excerpts from PSTs' responses to "pause to ponder" prompts in Heather's class, with the right-most column describing themes identified in the excerpts. This preliminary analysis of PSTs' experience engaging with the model unit suggests that curriculum analysis supports thoughtful engagement with the components of climate justice education in

elementary science. Through thematic analysis, we identified that curriculum analysis of *Watching Over Water* engaged PSTs in thinking about: a) the value of critical place-based pedagogy, b) understanding how and why to use Science and Engineering Practices to support sensemaking, c) the importance of community engagement for elementary science learning, and d) the role of elementary science education in building awareness of socioecological issues. These themes reflect PSTs' emerging understanding of what climate justice education can look like and accomplish in classrooms.

Table 1

Thematic Analysis of Pre-Service Teachers' Responses to Reflective Prompts

Prompt	Pre-service teachers' responses	Theme identified
1. How does the unit connect students to real-world climate change issues?	"Students will focus on local climate change and disruptions while also analyzing the actions that are taken by their community and organizations to reach water and climate justice."	**Critical place-based pedagogy:** PSTs explained the local relevance of the unit as connecting science learning and students' everyday lives
2. How does the unit build students' understanding of the science behind water issues and climate change?	"Students analyze data and text about the history of bodies of water which describe human and geological impact. They also focus on deep discussion on how to protect the environment and all life on the planet."	**Science practices:** PSTs explained how the practices of modeling and analyzing data support learning about climate issues while building foundational scientific knowledge
3. How does the unit encourage critical thinking and problem-solving about climate change and its impact on water systems?	"The unit supports creates community engagement with students as they analyze climate problems within their own communities to develop solutions and become agents of change (social justice)."	**Community engagement:** critical problem solving is prompted by uplifting community participation in collective action
4. How can your students see themselves as "water watchers" in their own neighborhoods?	"Students first need to acknowledge the importance of water to their survival and their community. This will motivate them to gather resources to take action to rejuvenate water ways in their community."	**Awareness building:** the role of the teacher is to help students become aware of issues

Case 2: **Megan's methods course**

This case is based on an elementary science methods course that Megan taught. The hybrid K–8 course, designed for multiple-subject credential candidates, included eight in-person sessions supplemented by asynchronous coursework and focused on preparing PSTs to design

equitable, NGSS-aligned science instruction. The university's mission emphasizes equity, community engagement, and environmental responsibility.

I integrated the *Watching Over Water* model unit as a culminating curriculum analysis near the end of the semester, allowing PSTs to draw on prior learning about the NGSS, instructional design, and inquiry-based teaching. The unit functioned as one example through which PSTs could examine how climate justice and equity commitments might be taken up within a science curriculum. Given limited in-person time, the experience combined asynchronous preparation with structured, inquiry-driven class activities.

In the weeks prior to the in-person class, PSTs completed readings and reflections on climate change education centering student agency, interdisciplinary learning, Indigenous ways of knowing, and commitments to equity and justice. For example, PSTs responded to prompts asking how climate lessons could "center student voice" or connect to community issues. This work served as an analytic framework for evaluating the *Watching Over Water* curriculum. The in-person session began with a whole-group discussion revisiting these ideas, with PSTs asking questions such as, "Where do students take action in this unit?" These discussion prompts focused PST on developing strategies to talk about the agency children and youth have in participating in justice-oriented solutions to climate change, representing the three dimensions of climate justice literacy.

PSTs then engaged in small-group analysis of the *Watching Over Wate*r unit, each group focusing on a concept from the companion guide. They annotated the curriculum, identified examples, and shared findings. For instance, one group highlighted how modeling water systems supported both science practices and community relevance. During share-outs, PSTs noted overlaps across concepts and connections to prior curriculum analyses, with one PST observing that "interdisciplinary learning shows up through both literacy and science tasks here" (aligned to the *science practices* theme in Table 1).

In the second half, PSTs worked in pairs to complete a curriculum analysis worksheet, reflecting on instructional coherence, student engagement, and opportunities for adaptation. For example, pairs discussed incorporating local water issues or community experts. They examined how the unit supported Science and Engineering Practices, made climate justice explicit, and could be adapted for different contexts. Pairs contributed insights to a gallery-style display to support collective sensemaking.

Throughout, *Watching Over Water* served as a focal case for connecting core concepts in my course. PSTs examined how the unit embedded Science and Engineering Practices and contrasted this with traditional instruction, with some noting that "students are figuring things out rather than being told" (aligned to the *awareness building* theme in Table 1). They also considered how to localize the unit using regional knowledge and community perspectives. Many noted how the unit demonstrated that climate justice pedagogy can align with the NGSS, supporting rigorous science learning while centering student voice, critical thinking, and socioecological responsibility.

A key challenge was limited instructional time, which required balancing depth with coverage of other course goals. Some PSTs initially struggled to apply abstract equity frameworks to the curriculum with which they were presented, often needing support to move beyond surface-level observations. This was addressed through targeted scaffolds, including guided prompts and collaborative sensemaking to deepen analysis within time constraints. Moving forward, I plan to explicitly model these frameworks across the course and provide additional opportunities for PSTs to apply them in their own instructional designs.

Teacher Educators as Agents of Socioecological Transformation

We view teacher educators as significant contributors to educational justice and transformation. To support teacher educators in this role, we developed a companion guide to support using the resources and practices outlined here (the guide can be found in the Supplemental Material or online at https://tinyurl.com/WatchingOverWater*).* This guide is oriented to teacher educators in California, but it can be applicable broadly. The *Watching Over Water* unit offers teacher educators an opportunity to work smarter, not harder, by engaging PSTs in applied learning experiences that address multiple Teacher Performance Expectations (TPEs) simultaneously. Rather than treating the TPEs as abstract standards, we position them as integrated, practice-based tools that meaningfully guide teacher education.

By embedding this unit into a methods course, teacher educators can model what standards like these TPEs look like in practice. As described in our case studies above, PSTs' learning is directly connected to California's TPEs. For example, PSTs analyzed a model of subject-specific lesson and unit plans (TPE 1) and practiced instructional strategies that promote inquiry and student sensemaking (TPE 4). The unit also provides opportunities for PSTs to design, analyze, and reflect on assessment practices aligned with instructional goals (TPE 5). Formative assessment is embedded throughout the unit via collaborative discussions and reflective questioning, while summative assessment is suggested as a culminating performance task in which students create public service announcements advocating for local water protection. Equity and justice are intentionally foregrounded through the integration of Indigenous histories, land stewardship, and youth activism connected to the Klamath River, as well as using children's literature authored by Indigenous writers. These features support PSTs in learning how to create inclusive learning environments that value students' cultural, linguistic, and community knowledge (TPE 2). In addition, the unit's emphasis on reflection supports professional growth (TPE 6). By critically examining how instructional decisions align with disciplinary learning goals and climate justice commitments, PSTs come to understand the TPEs as actionable, interconnected frameworks for designing meaningful, justice-oriented instruction. Through this approach, PSTs are not only introduced to what effective, equitable teaching entails, but they experience it firsthand and are supported in adapting similar practices for their future classrooms.

This article is an invitation to our teacher educator colleagues to be part of our collective efforts. PSTs must be equipped to teach young learners about climate change and environmental responsibility. We recognize that teacher educators, PSTs, and young learners face inequities and challenges in schools, universities, and society broadly. By embedding

climate justice education into TPPs as a tool of social justice education, we can support PSTs in understanding the interconnected nature of socioecological inequities and help them create equitable, climate-conscious classrooms. This approach fosters the knowledge and skills that are crucial for navigating the complex challenges of our changing world.

Our hope is that all teacher educators, in their commitment to the professional lives of teachers, will prepare PST to be agents of social change that can help youth build a just and sustainable world. We acknowledge that teacher educators are not required or trained to address grand societal challenges like climate change in our courses, and that we are all beholden to state credential requirements. The cases presented in this study illustrate how we exercise our own agency and creativity to teach our required teacher preparation courses while also transforming our courses into part of the solution to the climate crisis. We know that we are not alone in our desire to be part of the solution to climate change, and we hope you will join us in ensuring that teacher preparation rises to meet the challenges of this moment.

References

Alexander, B. (2023). *Universities on fire: Higher education in the climate crisis*. John Hopkins University Press.

Benevolenza, M. A., & DeRigne, L. (2019). The impact of climate change and natural disasters on vulnerable populations: A systematic review of literature. *Journal of Human Behavior in the Social Environment*, *29*(2), 266-281. https://doi.org/10.1080/10911359.2018.1527739

Berry, A., & Kitchen, J. (2020). The Role of Self-study in Times of Radical Change. *Studying Teacher Education*, *16*(2), 123-126. https://doi.org/https://doi.org/10.1080/17425964.2020.1777763

Beyer, C., & Davis, E. A. (2009). Supporting Preservice Elementary Teachers' Critique and Adaptation of Science Lesson Plans Using Educative Curriculum Materials. *Journal of Science Teacher Education*, *20*(6), 517-null. https://doi.org/10.1007/s10972-009-9148-5

Bocala, C., & Boudreault, P. (2020). Curriculum materials as mediating tools for teacher learning: A systematic review. *Journal of Curriculum Studies*, *54*(5), 627-648. https://doi.org/https://doi.org/10.1080/00220272.2022.2032954

Borgerding, L. A., Heisler, J. L., Beaver, B. C., & Prince, A. O. (2023). Secondary Science Teachers' Views and Approaches for Teaching for Climate Justice and Action. *Journal of Science Teacher Education*, 1-23. https://doi.org/10.1080/1046560X.2023.2265715

Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology vol. 2: Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 57-71). APA.

Brown, M. W. (2009). The teacher-tool relationship: Theorizing the design and use of curriculum materials. In J. T. Remillard, B. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics Teachers at Work* (pp. 17-36). Routledge.

Brown, M. W., Cochrane, S., & Jones, K. (2020). Curriculum materials in teacher education: Supporting the development of professional noticing. . *Teaching and Teacher Education*, *89*. https://doi.org/https://doi.org/10.1016/j.tate.2019.102996

Cochran-Smith, M. (2003). Learning and unlearning: the education of teacher educators. *Teaching and Teacher Education*, *19*(1), 5-28. https://doi.org/https://doi.org/10.1016/S0742-051X(02)00091-4

Cochran-Smith, M., Stringer Keefe, E., & Carney, M. C. (2018). Teacher educators as reformers: competing agendas. *European Journal of Teacher Education*, *41*(5), 572-590. https://doi.org/10.1080/02619768.2018.1523391

Davis, E. A., & Krajcik, J. S. (2005). Designing Educative Curriculum Materials to Promote Teacher Learning. *Educational Researcher*, *34*(3), 3-14. https://doi.org/10.3102/0013189x034003003

Davis, E. A., Palinscar, A. S., Smith, P. S., Arias, A. M., & Kademian, S. M. (2017). Educative curriculum materials: Uptake, impact, and implications for research and design. *Educational Researcher*, *46*(6), 293-304.

Donna, J. D., & Hick, S. R. (2017). Developing Elementary Preservice Teacher Subject Matter Knowledge Through the Use of Educative Science Curriculum Materials. *Journal of Science Teacher Education*, *28*(1), 92-110. https://doi.org/10.1080/1046560X.2017.1279510

Environmental and Climate Change Literacy Projects. (n.d.). *Framework for climate teaching and learning: 6 paradigm shifts*. Retrieved April 17, 2025, from https://teal-gold-jkmr.squarespace.com/6-paradigm-shifts.

Fantacone, D. (2024). Science and mathematics teachers' views of the characteristics of effective professional development: A Q methodological study. *Research Issues in Contemporary Education*, *9*(1), 77-113.

Fletcher, L., & Holyoke, E. (2025). Cultivating Critique, Hope and Action The Cordel as a Multimodal Invitation to Environmental Education Topics. *Climate Literacy in Education*, *3*(3).

Foley, J., Wilkinson, K., Frischmann, C., Allard, R., Gouveia, J. P., Bayuk, K., …., & Rodriquez, B. (2020). *The drawdown review: Climate solutions for a new decade*. Project Drawdown. https://doi.org/10.13140/RG.2.2.31794.76487

Gallay, E., Flanagan, C., & Parker, B. (2021). Place-Based Environmental Civic Science: Urban Students Using STEM for Public Good [Original Research]. *Frontiers in Education*, *Volume 6 - 2021*. https://doi.org/10.3389/feduc.2021.693455

Gallay, E., Furlan Brighente, M., Flanagan, C., & Lowenstein, E. (2022). Place-based civic science—collective environmental action and solidarity for eco-resilience. *Child and Adolescent Mental Health*, *27*(1), 39-46.

Garcia, A., Levinson, A. M., & Gargroetzi, E. C. (2020). "Dear Future President of the United States": Analyzing Youth Civic Writing Within the 2016 Letters to the Next President Project. *American Educational Research Journal*, *57*(3), 1159-1202. https://doi.org/10.3102/0002831219870129

Glaser, B. G., & Strauss, A. (1967). *The Discovery of Grounded Theory. Strategies for Qualitative Research.* Aldine.

Hickel, J. (2020). Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary. *The Lancet Planetary Health*, *4*(9), e399-e404. https://doi.org/https://doi.org/10.1016/S2542-5196(20)30196-0

Lee, C., Sulsberger, M., & Hansen, A. K. (2025). Innovations in sustainability education: Advancing climate and environmental literacy initiatives. *Innovations in Sustainablity Education*. https://doi.org/https://doi.org/10.5072/FK22V2QB4R

Remillard, J. (2018). Mapping the Relationship Between Written and Enacted Curriculum: Examining Teachers' Decision Making. Invited Lectures from the 13th International Congress on Mathematical Education, Cham.

Remillard, J. T. (2005). Examining Key Concepts in Research on Teachers' Use of Mathematics Curricula. *Review of Educational Research*, *75*(2), 211-246. https://doi.org/10.3102/00346543075002211

Salter, I., & Atkins, L. (2013). Student-generated scientific inquiry for elementary education undergraduates: Course development, outcomes and implications. *Journal of Science Teacher Education*, *24*(1), 157-177. https://doi.org/https://doi.org/10.1007/s10972-011-9250-3

Sleeter, C. (2017). Critical race theory and the whiteness of teacher education. *Urban Education*, *52*(2), 155-169. https://doi.org/https://doi.org/10.1177/0042085916668957

Sover, K., & Walsh, E. M. (2022). Climate change education must be education for justice: Historical and conceptual foundations for centering equity in climate change education. In E. M. Walsh (Ed.), *Justice and Equity in Climate Change Education: Exploring Social and Ethical Dimensions of Environmental Education* (1st ed., pp. 1-38). Routledge. https://doi.org/10.4324/9780429326011

Watkins, J., De Lucca, N. A., & Pao, S. R. (2023). Fostering expansive and connective sensemaking with preservice secondary science teachers. *Journal of Research in Science Teaching*, *61*(5), 1093-1133. https://doi.org/10.1002/tea.21922

