



Climate Education Pathways Project Report

Results of Project 2021 - 2026

Prepared by BSCS Science Learning
in partnership with
National Oceanic and Atmospheric Administration (NOAA)
and
Oregon Public Broadcasting (OPB)



Contents

Contents	2
Executive Summary	3
Project Overview	3
Examples of Local Adaptations	5
Methods	6
Student Outcomes	7
Teacher Outcomes	8
Implications and Impact	9
Next Steps	11

lessons around a local climate phenomenon, and at the end with culminating projects focused on local climate solutions.

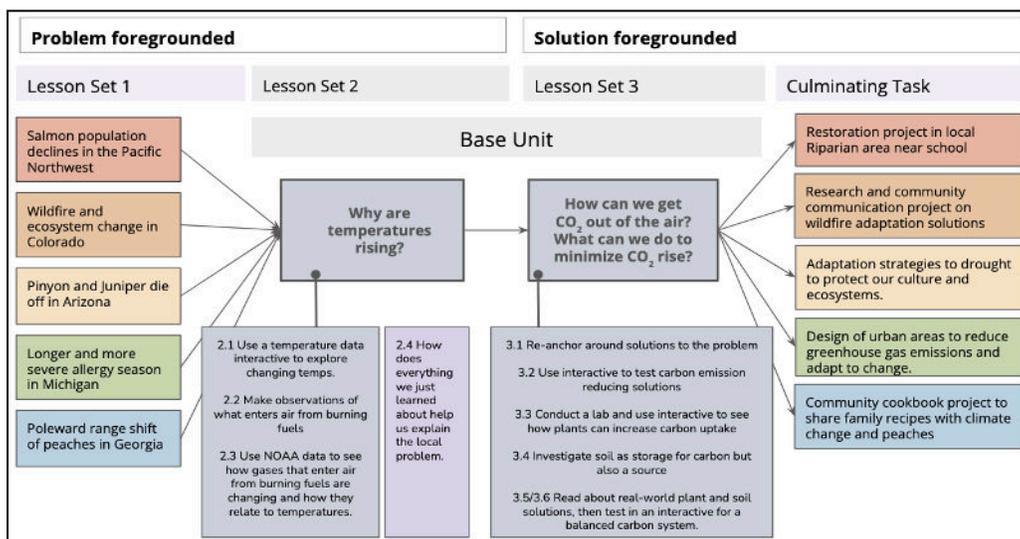


Figure 2. Structure of the Climate Education Pathways Unit

Quasi-Experimental Study. To study the impact of the Climate Education Pathways Unit on teacher and student outcomes, teachers participated in a cohort-controlled quasi-experiment where they acted as their own control. Teachers first taught climate change using their typical approach. They then participated in an intensive 60-hour professional learning program, delivered virtually from May through November 2023. The program combined synchronous collaborative sessions with asynchronous design work, helping teachers master both climate science content and strategies for making it relevant to students. Experienced mentor teachers who had previously implemented localized units provided real-world examples and practical guidance. During the professional learning program, teachers designed their own local pathways that connected the base unit's core climate science concepts to their specific community contexts and student interests. After completing their designs, teachers taught their localized version of the Climate Education Pathways unit to a new group of students.

Research Questions:

1. Does **knowledge of climate change** differ after high school students learn with a localized unit versus a business-as-usual unit?
2. Does **science identity** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?
3. Does a **sense of roles and expertise in science** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?
4. Does **foundation for change** differ after high school students learn with a localized unit versus a business-as-usual climate change unit?

Environmental Science Agency. The project was guided by the Environmental Science Agency (ESA) framework, which emphasizes three interconnected components: understanding

environmental science concepts and practices, identifying one's own expertise within environmental science, and using science learning experiences as a foundation for change in one's life or community. This framework helped teachers create learning experiences that build not just knowledge, but also students' sense of capability and connection to climate solutions.

Examples of Local Adaptations

Teachers successfully adapted the materials across diverse geographic and community contexts. In Georgia, one teacher integrated lessons about climate impacts on the local peach industry, culminating in students creating an educational cookbook that combined family recipes with scientific explanations. An Oregon teacher focused on declining salmon populations and orca habitat, leading students to partner with a local ranch on riparian restoration. In Vermont, a teacher leveraged their community's connection to local waterways, explaining:

Students spend a lot of time recreating at the river (swimming, fishing, etc.)... One student in particular is not very interested in school, but has been thoroughly engaged in the unit, so that was a plus! Students also drew on local connections during the solutions part of the base unit. Being a rural town in Vermont meant that students had a lot of personal connection to agriculture and forest management.

These examples demonstrate how the curriculum supported meaningful connections between climate science and local community priorities while engaging students who might not typically show strong interest in science. Figure 3 provides a detailed look at how one teacher structured their local pathway, integrating Next Generation Science Standards with investigations of wildfire impacts in their Colorado community. This example illustrates how teachers maintained rigorous science content while making meaningful connections to local climate phenomena.

Wildfire Storyline

Next Generation Science Standards Addressed in Local Pathway

Focal Performance Expectations

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Question and Phenomenon	What We Do	What We Figure Out
<p>1.1</p> <p><i>Why are there differences in forest recovery after a fire?</i></p> <p>Anchor 90 minutes</p>  <p style="font-size: small; text-align: center;">© iStockphoto.com</p>	<ul style="list-style-type: none"> Share personal connections to forest fires Examine images and headlines about forest recovery after fire. Look closer at a local case: the Hayman Fire located near Colorado Springs and the lack of recovery in this location. Develop initial models to explain why some forests benefit from and recover after fire and why some forests do not. Develop questions for the DOB and brainstorm ideas for investigation. 	<ul style="list-style-type: none"> Some forests recover quickly from forest fires while others do not seem to recover as quickly. There are claims that forest fires can be both bad and good for the forest. The Hayman Fire hasn't seen much recovery of the original plant populations but some other plants are thriving. We have lots of questions about how and why some forests recover after fire while other forests do not.
<p>1.2</p> <p><i>How can plants survive and regrow after a fire?</i></p> <p>Investigate</p>  <p style="font-size: small; text-align: center;">© iStockphoto.com</p>	<ul style="list-style-type: none"> Read about local plant adaptations and jigsaw to share with each other. Watch videos showing forest regeneration and adaptations. Examine data on Hayman forest regrowth compared to other fires. Read about healthy forests and fire 	<ul style="list-style-type: none"> Colorado plants are fire-adapted and it's normal, even necessary, for them to experience a fire. Seeds are essential to regrow the forest. High-severity fires kill the trees and result in fewer seeds available to regrow.

Wildfire Storyline
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Figure 3. Example Local Pathway: Colorado Wildfire Storyline

Methods

Instrument development. Prior to the quasi-experiment we developed, piloted, tested and validated three instruments, including:

1. **Climate Change Knowledge Assessment (RQ1):** We developed a three-dimensional transfer task using the assessment design protocol from Harris, Krajcik, Pellegrino, and McElhaney. This assessment consists of 20 multiple-choice questions and 4 open-response questions to evaluate students' knowledge of climate change and its impacts.
2. **Science Identity Measure (RQ2):** We created a novel instrument to assess students' science identity, motivation, and contribution within science class. The instrument comprises 13 Likert-scale items: 10 core items administered to all students, plus 3 items randomly assigned from a pool of 6 additional items.
3. **Sense of Roles and Expertise in Science Measure (RQ3):** We developed an instrument to evaluate students' enjoyment of engaging in various classroom role-related activities across two hypothetical science-based scenarios. The instrument includes 29 Likert-scale items: 17 core items administered to all students, plus 12 items randomly assigned from a pool of 24 additional items.

Existing Measure. To measure foundation for change (RQ4), we used the Transformative Experience Questionnaire, or TEQ (Littrell et al., 2022), which was adapted for climate change. The TEQ evaluates how students' learning extends beyond the classroom and captures their ability to apply learned concepts in external contexts, perceptual changes on climate change topics, and the value they perceive in new learning opportunities. The instrument consists of nine items on the pretest and fifteen on the posttest.

Rasch analysis. We employed Rasch modeling techniques using Winsteps to estimate item and person measures. Specifically, we used a partial credit Rasch model for the knowledge assessment, which contains items scored as correct or incorrect. For the three other measures consisting of polytomous items, we applied the Rasch Rating Scale Model. Item and person measures are reported in logits, with zero representing the average item difficulty. Eight measures were calculated for each person using the pre and post-test data from each instrument.

Mixed-effects models.

We used Stata 15 (StataCorp, 2017) to estimate two-level random-intercept models (students nested within classrooms) to investigate the impact of individual and class level factors on each of our research questions' outcome. We used Rasch person measures as the dependent variable, while controlling for other variables related to student demographics, classroom characteristics, and teacher-specific effects. We used the model's coefficients and standard errors, which were estimated at the classroom level, to estimate effect sizes, calculating Hedges' *g* for student outcomes and Cohen's *d* for teacher outcomes.

Student Outcomes

Our research compared outcomes between students who experienced their teacher's typical climate change unit versus those who experienced the localized Climate Education Pathways unit. The study included 2,062 students across 143 classrooms from the 25 participating teachers. The study revealed significant positive effects in two critical areas. In answer to Research Question 1, we found that students who experienced the localized curriculum showed substantially higher performance in climate science knowledge compared to those in traditional instruction (Hedges' $g = 0.278$). Based on the What Works Clearinghouse Improvement Index, students who participated in the localized unit would be expected to outperform their peers by 11 percentage points on average in assessments of climate science understanding (Figure 4).

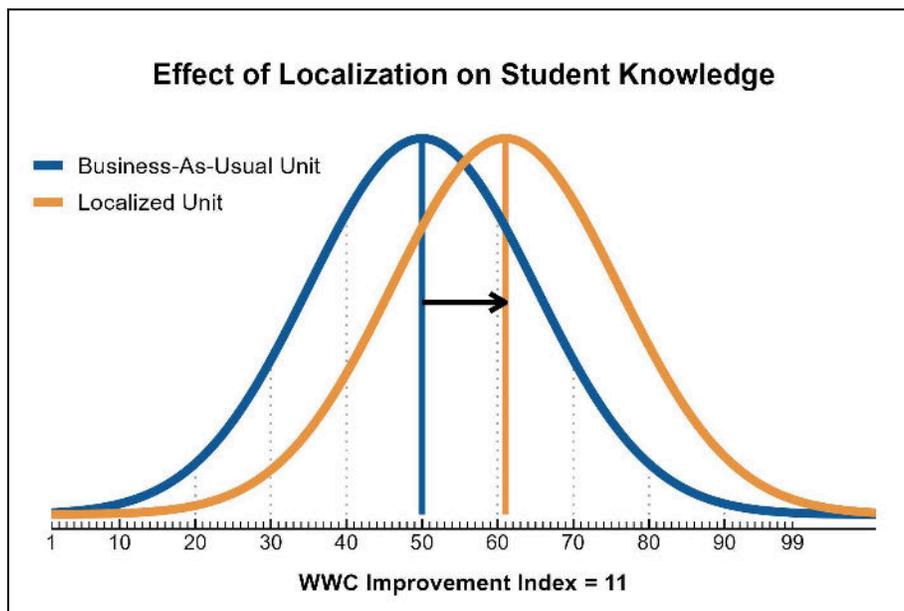


Figure 4. Effect of Localization on Student Knowledge

In answer to Research Question 4, we found similarly significant improvements were seen in students' foundation for change - their ability to apply learning beyond the classroom and engage in climate solutions (Hedges' $g = 0.126$). Students experiencing the localized curriculum showed distinctly higher scores in this area, with the Improvement Index indicating they would outperform peers by 5 percentage points on average.

In answer to Research Questions 2 and 3 we found that while there were positive trends observed in students' sense of roles and expertise in science and their science identity, these differences were more modest ($p > 0.05$). However, analysis revealed an important connection between students' science identity and their foundation for change, suggesting that students who identify more strongly with science may be more inclined to see themselves as capable of leveraging their climate learning for action.

These findings suggest that localizing climate change education can effectively bridge the gap between knowledge acquisition and readiness for action, particularly when students can connect global climate science to issues affecting their own communities.

Teacher Outcomes

The professional learning component of the project showed substantial positive impacts on teacher growth across multiple dimensions. Teachers increased in all measured aspects of their confidence from Pre, before teaching their business-as-usual unit, to Post, after teaching their localized unit, including their confidence in:

1. NGSS design and facilitation (Cohen's $d = 0.779$)
2. tapping into relevance and localization (Cohen's $d = 2.067$)
3. teaching climate change (Cohen's $d = 1.563$; Figure 5)

For both confidence for tapping into relevance and localization and confidence for teaching climate change, teachers showed initial gains after completing the professional learning, with continued growth through their implementation of the localized units. This pattern suggests that both the structured learning experiences and the supported classroom implementation contributed to teachers' growing confidence. Interestingly, teachers' confidence in implementing NGSS-aligned instruction followed a different pattern - showing minimal change immediately after professional learning but demonstrating significant growth after implementing their localized units. This delayed growth in NGSS confidence suggests that teachers may need hands-on experience implementing phenomenon-driven, three-dimensional instruction to fully develop their confidence with these teaching approaches.

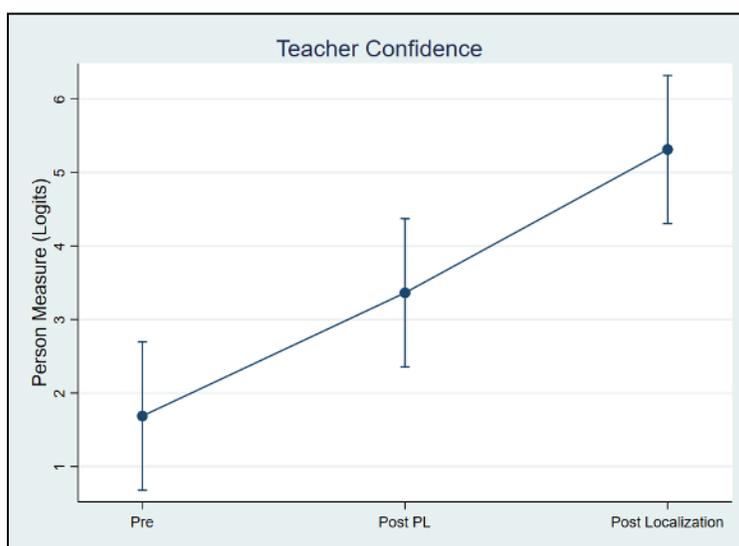


Figure 5. Teacher Confidence for Teaching Climate Change

Teachers also demonstrated significant growth in their climate science content knowledge (Cohen's $d = 0.505$ from Pre to Post Localization), with average scores increasing from

pre-program to post-implementation (Figure 6). This growth in content knowledge occurred despite many participating teachers already having strong science backgrounds, indicating the program's ability to deepen understanding even among experienced educators.

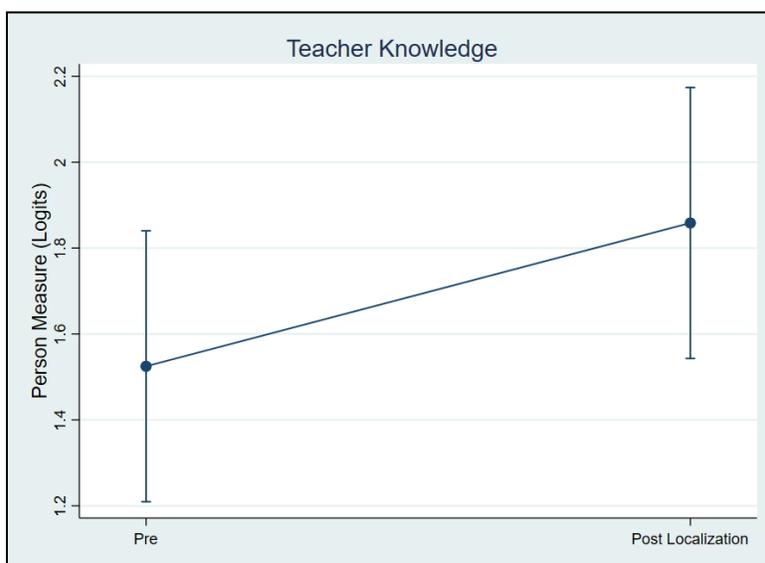


Figure 6. Growth in Teacher Content Knowledge

These improvements in both confidence and knowledge were maintained through the implementation phase, suggesting that the professional learning provided teachers with lasting tools and understanding rather than just temporary boosts. The continued growth during implementation particularly highlights the value of combining professional learning with supported classroom practice. One participant explained how the professional learning experience had a transformative effect on their confidence and capabilities:

I had been concerned that I needed to understand ALL the climate science in a lot of depth to adequately teach it in the classroom. [The PL] helped me gain clarity in both teaching using storylines and in the content critical to making sense of the causes and solutions for climate change.

Implications and Impact

The Climate Education Pathways project demonstrates several important insights about effective climate change education in high school science classrooms. First, the study shows that connecting global climate science to local phenomena and solutions can significantly enhance both student learning and engagement. When students examined climate change through the lens of their own communities - whether that was declining peach harvests in Georgia or salmon habitat loss in Oregon - they demonstrated stronger content knowledge and a greater sense that they could contribute to climate solutions.

The project also highlights the value of supporting teachers in curriculum customization. Rather than providing fully prescriptive materials, giving teachers structured opportunities to integrate their knowledge of local contexts and student interests proved powerful. Teachers reported that this approach helped them make climate science more relevant and meaningful for their students while maintaining rigorous content instruction. The professional learning model demonstrated that teachers can successfully undertake this kind of customization when provided with appropriate support structures and collegial collaboration opportunities. Teachers found this approach transformative for their practice. As one educator reflected:

While I may have THOUGHT that I had a good grasp on using local phenomenon and storylines, and helping students with sensemaking, it was not until I utilized this curriculum that I realized how little I knew or did these things effectively. I now feel much more comfortable with designing and engaging students with this technique. Students were genuinely interested and researching on their own, having relevant conversations that were spontaneous and lively.

Another key finding relates to student agency. The project's focus on Environmental Science Agency (ESA) - helping students develop not just knowledge but also expertise and capacity for action - offers a promising framework for science education that connects to students' lives beyond the classroom. Students who experienced the localized curriculum showed significant gains in their foundation for change, suggesting they were better prepared to apply their learning to real-world situations.

The digital tools developed through the project proved effective across diverse classroom settings. Interactive data visualizations and modeling tools helped make complex climate science concepts more accessible and engaging for students, while maintaining flexibility for different technology environments. This suggests that carefully designed digital resources can enhance climate science instruction without requiring extensive technology infrastructure.

Perhaps most importantly, the project demonstrates that it's possible to address climate change in ways that are both scientifically rigorous and locally meaningful. As one teacher noted:

Utilizing a local phenomenon to anchor my educational content has significantly enriched the level of engagement I experience with my students. When students can personally relate to the subject matter, their understanding of scientific concepts deepens, moving beyond abstraction. Despite the challenges posed by the contentious nature of teaching topics like climate change, integrating a narrative around a local phenomenon empowers students to explore, form independent opinions based on evidence, and break away from simply parroting parental views.

The positive outcomes in both student learning and teacher growth suggest this balanced approach can effectively support climate change education in high school science classrooms. These findings contribute to our understanding of how to support meaningful climate change

education that connects global issues to local contexts while building students' capacity for informed action. The project's success across diverse geographic and socioeconomic contexts suggests these approaches can work in a wide range of high school science classrooms.

Next Steps

The success of the Climate Education Pathways project offers clear opportunities for district-wide implementation of these materials and approaches. Please explore the resources at <https://bscs.org/climate/>. Contact the team if you are interested in discussing opportunities to scale and spread this learning opportunity to more teachers and students in your district or region.

This material is based upon work supported by the National Science Foundation under Grant #2100808. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.