Impacts of professional learning to support teachers' design capacity for localized climate units

Abstract. Creating localized, meaningful climate learning for youth is a high need for teachers and schools. Responding to this need, we designed and tested a curriculum adaptation approach to localizing climate change curriculum materials. We provided teachers with a phenomenon- driven, three-dimensional climate change storyline unit that was 75% complete. We supported teachers in professional learning (PL) to design and localize the remaining 25% of the unit. The goal of the PL was to build teachers' pedagogical design capacity for implementing phenomenon- driven storyline units localized for student relevance. We report on the PL design and its impact on our sample of 25 high school teachers from across the US. Teachers had a significant increase in climate change content knowledge coupled with significant increases in confidence for teaching climate change and enacting phenomenon-driven learning strategies that tap into relevance. Teachers' confidence for enacting phenomenon-driven learning strategies was not significant immediately following the PL but became significant after teachers enacted localized units. Teachers continued to see gains in knowledge and confidence from post PL through enactment, indicating the importance of coupling PL with enactment of reform-oriented materials. We discuss these findings further and limitations of this study.

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Impacts of professional learning to support teachers' design capacity for localized climate units

Subject/Problem

Climate education is arguably one of the most pressing needs in science education in the 21st century with over 3 billion people worldwide and a high proportion of species living in contexts highly vulnerable to climate change (IPCC, 2022: Summary for Policymakers). Climate education is one of the most impactful strategies to reverse our current trajectory (Project Drawdown, 2023) and despite its polarization in America, 78% of registered voters in America support climate education (Leiserowitz et al., 2021).

It is troubling that even though 75% of US science teachers report teaching climate change, they also report a lack of coherent, unbiased curricula and access to professional learning (Melia, 2019; Plutzer et al., 2016). Several high-quality, standards-based programs now exist to respond to this need for coherent curriculum (e.g., iHub, OpenSciEd, MBER, CarbonTIME). Teachers have used these materials to help students improve their scientific understanding of climate change (e.g., Anderson et al., 2018; McNeill & Vaughn, 2012; Author et al., 2009; Zangori et al., 2017). Though critical, improving science understanding is not sufficient. It can shift beliefs about climate change (Zummo et al., 2021), but it does not always result in willingness to change behaviors (Schweizer et al., 2013; Knutti, 2019). Other researchers have argued that climate education needs to also foster concern about the problems we face but create a sense of hope that we can solve them (Ojala, 2012; Smith & Leiserowitz, 2014; Stevenson & Peterson, 2016; Zummo, et al., 2020).

One way teachers can foster concern about climate change along with student agency and hope is to create learning experiences that students find meaningful to their lives and communities (Lee & Grapin, 2022; Monroe et al., 2019). These approaches help learners develop a closer psychological connection to the problem, which is correlated with greater concern and mitigation behavior (Busch & Chavez, 2022). The CLIME TIME project is an example of curriculum materials that support teachers with facilitating learning about climate change in their lives and communities with local action as a central component (e.g., https://www.climetime.org/). Yet, the resources, time, and partnerships invested in this project are not widely available. While research has shown that teachers who situate science learning in the context of the local community can make learning meaningful to their students (e.g., Adah Miller et al., 2022; DeBarger et al., 2013, 2017; Torres Olave & Dillon, 2022), an open question remains: How do we get more localized climate learning resources to support teachers?

Theoretical framework. Given the benefits of localized resources and the limitations on widespread reach, we turned toward curriculum adaptation, particularly *pedagogical design capacity* (PDC) as a way to explore this challenge. PDC involves teachers leveraging curricular resources alongside their own teacher resources to design instruction (Brown & Edelson, 2003; Brown, 2009; McNeill et al., 2018; Penuel et al., 2009; Remillard, 2005). Professional learning (PL) is part of that participatory relationship and can support teacher growth, particularly teachers' science teaching self-efficacy, content knowledge, and beliefs about science teaching and learning (Granger et al., 2018).

With this framework, we designed and tested a phenomenon-driven storyline "base unit" for teachers to adapt and PL to build teachers' knowledge, confidence, and design capacity for adapting a unit to include local climate change problems and incorporate local solutions. This poster reports on the PL program and its impact on teachers. Our research question is: *How does a professional learning program designed to support curriculum adaptation impact teacher knowledge and confidence for designing phenomenon-driven, localized climate education materials?*

Design and Procedure

Study context and participants. This study took place as part of a two-year cohort-controlled quasi-experiment in which teachers first taught a "business-as-usual" (BAU, non-localized unit) climate change unit in spring of 2022-2023, and then participated in PL to design a localized unit in summer and fall of 2023 that they enacted the following spring 2024 with students (localized unit). We collected data from 25 high school science teachers in the United States. Teachers came from diverse communities concerning race, economics, geography, climate change impacts, and support for teaching about climate change. They also represented a range of years teaching experience (2-31 years) and low anxiety for teaching about climate change.

PL design. The PL program goal was to prepare teachers to design and facilitate a localized climate unit. To support them, we developed a 10-lesson "base unit" that was 75% complete. It included 4 lessons focused on understanding the causes and extent of global temperature change and 6 lessons making sense of carbon cycling and how proposed solutions work in this system. Teachers designed the other 25% of the unit to include a localized climate problem to anchor the unit and local solutions and action, all of which were congruent with the base unit. We refer to the materials teachers designed as their "local pathway."

To help teachers understand the base unit and design their local pathway, we designed an 60+ hour PL course that drew on design features for high-quality PL, such as including activities for teachers to participate as learners (e.g., "immersion"), collaboration structures for working with colleagues and the research team, videocase analysis, and coaching and feedback (e.g., Borko, 2004; Darling-Hammond et al., 2017; Garet et al., 2001; Loucks-Horsely et al., 2009; Reiser et al., 2017). We added PL components to support localization design, such as design feedback cycles from fellow teachers and a coach from the project team, tools and templates to support design work, examples of teacher-designed adaptations from a previous pilot study and interactions with those teachers about their designs, and organized small groups who were designing similar materials. The PL occurred from May to November of 2023 with synchronized sessions and asynchronous design work (see Table 1).

Table 1. PL design features guiding learning activities

Synchronous time (35 hours)
● Participate in base unit lessons as learners (e.g. "immersion") ● Collaboration and feedback from peers, mentor teachers, and a storyline coach on works in progress ● Curriculum analysis of example localized pathways ● Curriculum design tools including templates and tools to design localized unit using a phenomenon-driven instructional approach ● Video-based lesson analysis
Asynchronous time (25+ hours)
● Independent time for design using tools and templates ● Feedback from a storyline coach on works in progress

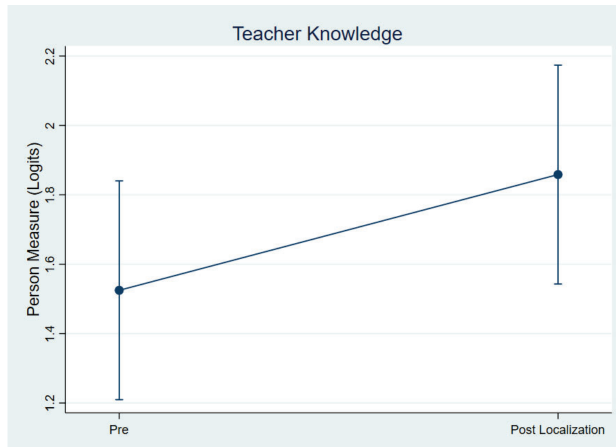
Data Collection. Data came from three sources (see Table 2 for example items).
1. *Climate change knowledge measure*: The knowledge measure assessed teacher understanding of concepts and practices relevant to climate change and was administered at two time points. The first time point was prior to BAU enactment (Pre) and the second time point at the completion of enacting the localized unit (Post Localization).
2. *Confidence surveys:* Surveys assessed teachers' confidence for teaching climate change, enacting phenomenon-driven learning strategies, and tapping into local relevance and students' interests and experiences (adapted from Reiser et al., 2017). These were administered at three time points. The first time point was prior to BAU enactment (Pre), the second time point occurred at the completion of the PL to design their localized units (Post-PL), and the third time point at the completion of enacting the localized unit (Post Localization).
3. *Teacher reflections:* Teachers completed reflections at the end of each synchronized PL session and in a post PL survey.

Table 2. Sample Items

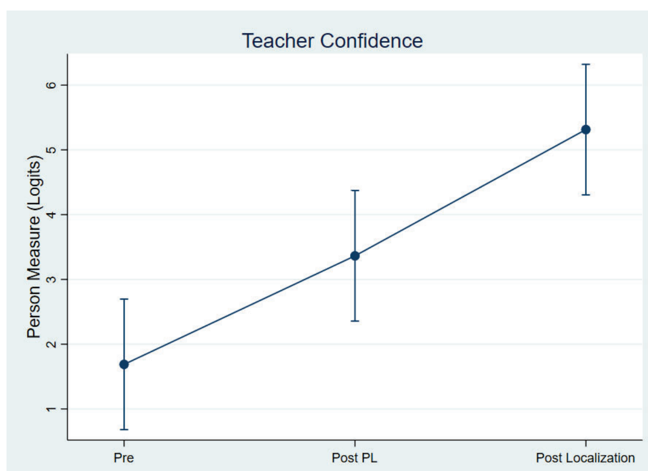
Survey	Example Item(s)
Knowledge	Where do you think that most of the carbon atoms in tundra plants come from? Which is the best definition of a positive feedback loop in the climate system?
Confidence for phenomenon driven learning	Please respond with your level of confidence when using the following items in a classroom setting: ● Using phenomena to motivate science instruction ● Helping students develop explanations about science phenomena over several lessons
Reflection	What went well in the professional learning that you found helpful?

Data analysis. To examine changes in teacher knowledge and confidence we transformed raw scores from each survey to Rasch person measures, or logits, which were then used in mixed-effects maximum likelihood regression models. Teacher reflections were used to better understand and further elaborate on the findings from the knowledge measure and confidence surveys.

Findings

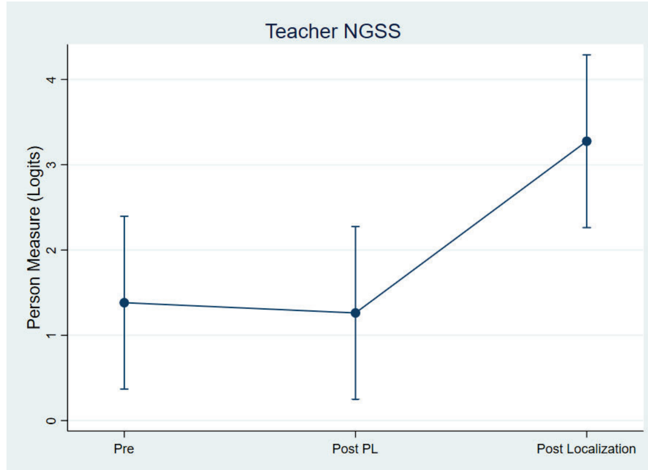


Climate Change Knowledge. The analysis revealed a significant increase in teacher knowledge Post Localization (Coef. = 0.3336, z = 2.29, p = 0.022) compared to their Pre levels. Baseline confidence levels varied among teachers, with a variance estimate of 1.52 logits. Teachers did not receive climate science instruction in the PL, but rather experienced science as they participated in lessons as learners and reflected on how to implement the lessons. One teacher described, "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. This 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."

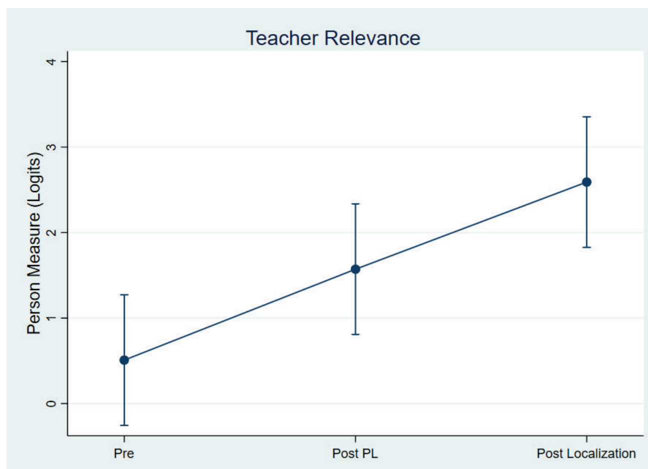


Confidence for teaching climate change. The results indicate significant effects for both Post-PL (Coef. = 1.676, z = 3.35, p = 0.001) and Post-Localization (Coef. = 3.6256, z = 7.24, p < 0.001) compared to pre-implementation. Baseline confidence levels varied among teachers, with a variance estimate of 1.68 logits. One teacher described the increase in confidence on how she can prepare students with "the skills they need to engage in these conversations as they go into the world. They are able to listen with intent and understanding, as well as justify their view."

Confidence for phenomenon-driven learning. The results indicate a non-significant effect for Post-PL (Coef. = -0.12, z = -0.23, p = 0.817) and a significant effect post-localization (Coef. = 1.8932, z = 3.64, p < 0.001) compared to pre-implementation. Baseline scores varied significantly among teachers, with a variance estimate of 3.30 logits. A focus of the PL was directed toward getting teachers comfortable with a phenomenon-driven, storyline style instructional approach. One teacher described, “I appreciate the modeling by teachers for how to teach in this fashion: phenomenon-based, student driven. That is probably the scariest part,” and “It added confidence to see so many other teachers being successful. This is my first time utilizing this teaching style.”



Confidence for tapping into relevance. The analysis showed significant effects for both Post-PL (Coef. = 1.0632, z = 3.01, p = 0.003) and Post-Localization (Coef. = 2.0824, z = 5.89, p < 0.001) compared to pre-implementation. Baseline relevance scores varied among teachers, with a variance estimate of 2.23 logits. A second significant focus of PL was to localize a unit to make it more relevant to place and students. Teachers remarked frequently about this impacting them. One teacher explained that “this helped me gain confidence in my ability to continue writing curriculum that is relevant to my students,” and another teacher reflected that she now believes “when students see the relevance to their daily lives, hopefully they will become passionate about change...and hopefully they will see that small changes can make a difference.”



Discussion and contributions to the teaching and learning of science

Our findings indicate that the PL course was successful in improving teachers’ climate change knowledge and confidence for teaching climate change using a phenomenon-driven approach that taps into relevance for learners. The findings further support the transformation that occurs for teachers using reform-oriented curriculum materials coupled with curriculum-based PL (Short & Hirsch, 2020). Teachers continue to grow in their knowledge and confidence when they put into practice the new understandings they develop during PL.

We did not anticipate seeing a significant change in teacher content knowledge given that the PL did not emphasize content knowledge. Teachers were immersed in lessons as learners, developed models and explanations for climate change phenomena, and used an educative teacher guide to enact a new unit. These components may have helped teachers understand the instructional approach while also building their climate change content knowledge. This adds to prior literature that activities to engage teachers in lessons as learners as well as educative curriculum materials can support teachers' content knowledge (Davis & Krajcik, 2005; Desimone, 2009; Greenleaf et al., 2011).

There was a slight dip in confidence to enact phenomenon-driven learning post PL, though not significant. Confidence to enact this instructional approach increased significantly post enactment, which mirrors research showing non-significant gains immediately following PL and significant gains months later (Meichtry & Smith, 2007). This finding adds to research that a significant increase in teachers' self-efficacy to implement phenomenon-driven instruction requires time (Lowell & McNeill, 2023). Our teachers' reflections revealed excitement for the new approach, but also apprehension. Enacting new strategies with success was a confidence booster for them more so than learning about and designing with them alone.

Limitations. Caution is warranted in interpreting these results as definitive impacts of the intervention due to the absence of a control group. Other factors, such as concurrent professional development initiatives or external influences, may have contributed to these observed changes.

Conclusion. Our ultimate goal is to expand access to localized climate curriculum materials. This study looked at curriculum adaptation as an approach to this problem. Our findings revealed that professional learning to support teachers in curriculum adaptation and design can improve teacher content knowledge while also supporting teachers' confidence to design and enact phenomenon-driven learning with a focus on relevance for their learners. The science teachers we worked with were essential partners, bringing their knowledge to the design work and commitment to creating meaningful learning for their students. What resulted was 25 unique localized climate units customized for their students and community.

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