

Article

Centering Educators' Voices in the Development of Professional Learning for Data-Rich, Place-Based Science Instruction

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Abstract: This self-reflective case study describes our project team's efforts to promote equity in science professional learning (PL) by centering the voices of educators in the PL design process and within the course itself. We believe that educators' experiences, priorities, and expertise are essential to developing professional learning that meets the needs of teachers and their students. We have a particular interest in amplifying the voices of those in historically underrepresented communities. Toward that end, we engaged science educators who work with Indigenous students and recent immigrants as collaborators in developing PL to support data-rich, place-based Earth Science instruction. In this case study, we share and critique the practices and tools that we have employed to center educator voices, rather than those of the PL designers and researchers. Our strategies for developing more equitable science professional learning include the use of: (a) equity-focused research methods, such as asset-based needs-sensing questions and peer-to-peer interviews; (b) a humanistic stance toward data-rich science learning, which emphasizes the typically unnamed sociocultural inputs and outputs that permeate all aspects of data; (c) a participatory design process that centers educator voices; and (d) a model of professional learning that uses representations of educator and student experiences as objects for reflection.

Keywords: equity; participatory design; professional development; science education



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1. Introduction

1.1. Overview

Our work takes place in the context of an ongoing project called Broadening Data Fluency Through the Integration of NASA Assets and Place-Based Learning to Advance Connections, Education, and Stewardship (PLACES), which has the goal of designing and disseminating professional learning (PL) that supports teachers in bringing place-based, data-rich instruction into their Earth Science classes. Our team's long-term goal is to help students improve their "data fluency", which we define as the ability and confidence to actively make sense of and use data. We have a particular interest in supporting teachers who work with Indigenous students and those who are recent immigrants.

Rather than reporting about project findings related to teacher or student outcomes, this self-reflective case study critically examines our team's own research and development processes in order to share and critique the practices and tools that we have employed to center educators' voices. In documenting and sharing our efforts so far, we hope to invite conversations with other researchers and developers about practical efforts to center historically underrepresented voices in science PL.

1.2. Challenges to Equity in Science Professional Learning

Professional learning plays a key role in systemic efforts to address educational inequity: these are valuable spaces where norms, values, beliefs about students, pedagogy, and disciplines, such as science and data science, are negotiated and reinforced. The field of

education faces three challenges to equity in science and data science professional learning, as follows:

1. Traditional models of professional learning (PL)—where the content, structure, and outcomes of learning opportunities are solely determined and produced by researchers and PL developers—can perpetuate asymmetrical power relations by centering the views of the dominant culture. Herr and Anderson raise the concern that “a [professional learning] focus on how to conduct business as usual in schools without concurrent questioning and critical problematizing will leave unaddressed whole groups of students” [1] (p. 383). Equitable PL should center the perspectives of and account for the priorities, strengths, and needs of the educators and students who are most affected by the intervention, particularly those whose voices have been historically unheard.
2. Science and data science are often falsely considered objective, unbiased, or neutral [2–10]. In educational settings, data are often “instructionally treated as apolitical and, when collected through accepted normative processes, inherently authoritative” [11]. These beliefs are dangerous. Positioning science and data science as endeavors devoid of human decisions masks racist and other biased practices that may underlie these enterprises; for example, the use of racially biased datasets in predictive policing systems [12], hidden bias in AI systems for science education assessment that perpetuates inequities in education [13], and discriminatory designs in computer programming that unwittingly contribute to greater social inequity [14]. Professional learning that codifies the myth of data objectivity upholds the status quo in ways that reproduce educational injustices. Equitable science and data science PL should acknowledge the role that humans play in the production and use of data, including relevant contexts and potential sources of bias.
3. An overemphasis on objectivity results in the devaluation of alternative ways of knowing and the lived experiences of individuals impacted by or involved with the data. Qualitative data types, such as historical journals, first-hand accounts, storytelling, and other oral traditions, can be cast aside as less true than quantitative data. By disqualifying these forms of evidence, users of data run the risk of stripping away the nuance and complexity of the systems that they are trying to model. This challenge is especially salient when working with members of groups who have been marginalized, such as Indigenous communities. Based on their work with native communities in Alaska, Barnhardt and Kawagley [15] characterize traditional Indigenous knowledge systems as prioritizing direct experience in the natural world, the concept of interdependence, the importance of place, observation, and storytelling. They contrast Indigenous knowledge systems with Western knowledge systems, which prioritize de-contextualized, compartmentalized knowledge. The unquestioned dominance of normative, Western ways of knowing can disenfranchise students [16]. We can “rehumanize” STEM education [17] by embracing varied forms of knowledge and ways of knowing. Toward that end, equitable science and data science PL should include educators’ and students’ lived experiences as one resource for sense making and learning.

Our project team heeds the call by Madkins and Nazar [18], to move beyond assimilationist paradigms in science education by developing a professional learning course that centers the voices of educators, and uses a participatory design process to do so.

1.3. Centering Educators’ Voices in Professional Learning

What does it mean to “center the voices” of educators? We use the following definition from the Centering Voices Workgroup [19]:

Uplifting, trusting, and valuing the lived experiences of the people most impacted by the issue(s) and inequity(ies) you want to address. This includes working towards approaches where those that are most impacted are a part of leading, identifying solutions, setting priorities, creating policy agendas, and shifting narrative. (p. 1)

The Centering Voices Workgroup [19] articulated a set of 14 principles for centering the voices of those most impacted by health initiatives, as quoted in Figure 1. Taken together, these principles serve as a guide for our self-reflective inquiry into our team's practices to center educators' voices during the design of a professional learning course intended for educators. We place particular emphasis on the ways our work: (1) attends to the lived experiences of educators and their students, (2) encourages and supports educators to hold meaningful roles in the design of PL, (3) employs methodologies that center the most marginalized, and (4) seeks to understand and disrupt barriers related to structural factors and power that are common in research and development practices.

1. Centering Voices affirms the lived experience of the individual(s) most impacted by the issue(s) and does not dismiss those experiences in regard to statistics or theories.
2. Centering Voices affirms the lived experience as a credible form of evidence.
3. Centering Voices must recognize the unique challenges that those impacted may go through and strive to reduce barriers to participation and leadership.
4. Centering Voices and perspectives leads to the empowerment of marginalized communities and not just the empowerment of individuals.
5. Centering Voices demands compassion.
6. Centering Voices opposes the usage of tokenization of those most impacted and challenges the practice of burdening one or a few individuals to speak on behalf of groups and recommends meaningful roles and positions for those most impacted.
7. Centering Voices requires acknowledging common experiences across groups, while honoring the fact that all individuals hold multiple, intersecting identities and have unique life experiences.
8. Centering Voices requires active listening.
9. Centering Voices requires engagement of folks with lived experience, with the types of inequities previously described, across a spectrum of roles, including as community members and as experts who have a body of work or study AND also lived experiences. This means bringing in keynote speakers, expert statisticians, technical assistance consultants, etc., who are members of the most impacted communities.
10. Centering Voices requires changing not just who is engaged, but how work is conducted by prioritizing theories, methodologies, and approaches that center the most marginalized people (e.g., feminist, racial justice, anti-racist, place based/tailored, anti-sexism, economic justice, etc.). Efforts cannot just involve folks experiencing the inequity present in the system with the same bad approaches and politics, and think that will change the outcomes.
11. Centering Voices requires a deep understanding of the structural factors and power, including but not limited to, an analysis of class and poverty, economies and occupations, race, gender, and place, including rural and urban contexts.
12. Centering Voices involves addressing power and the power imbalance.
13. Centering Voices demands resources and long-term commitment.
14. Centering Voices requires action. Start from where you are. Recognize where you may have struggled and also your assets. Be transparent with your intentions and commitment. Set shared goals. Determine how you will build upon relationships and manage tension. Be prepared to learn.

Figure 1. Principles of Centering Voices of Those Most Impacted.

2. Materials and Methods

This paper employs a case study methodology [20] to create an in-depth, self-reflective account of our team's approach to designing science PL. We aim to provide the reader with an understanding of our processes [20,21], identify the ways our work reflects equitable development practices, and provide a critique of our efforts. This analysis engages the members of the project team in the case study process through interviews, collaborative analysis, and member checking.

2.1. Data Sources

The analysis draws from project artifacts, including research and development plans, meeting notes, research memos, project correspondence, research instruments, recruitment documents, researcher reflections, and unstructured interviews with project staff.

2.2. Project Context

The PLACES project is a 4-year research-based development effort. This project has the primary goal of developing and disseminating professional learning to support middle and high school teachers across the U.S. to incorporate a data-rich instruction into Earth Science learning. Additionally, the project strives to increase opportunities for underserved students in middle and high school to use data and data tools, while elevating students' backgrounds, cultures, and prior experiences. This project has a particular focus on supporting Indigenous students and those who are recent immigrants.

The project is a joint effort by a large team of researchers, developers, professional learning specialists, science leaders, and scientists from across the United States. Partners include WestEd and the Making Sense of SCIENCE Professional Learning project, GLOBE Mission Earth, the Gulf of Maine Research Institute, NASA Langley Research Center, and the Northern Arizona University's Center for STEM Teaching and Learning. The project is evaluated by Magnolia Consulting. In the first year, this project-based team also recruited a cohort of educators to work alongside the project-based team as co-developers of the PL course.

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2.3. Timeframe and Participants

While the entire project spans a four-year period (January 2022 through December 2025), this case study documents the activities that transpired during the first 16 months of the project: the PL development period. In this paper, we will refer to this period as "Year 1". The remaining three years of the project focus on the pilot testing and dissemination of the professional learning course, but they are not the focus of the current study.

The participants in this study represent five teams who each contributed to the PL development: a Development Team, a Research Team, a Leadership Team, a group of Site Coordinators, and a cohort of Educator Co-Developers. These groups and their key responsibilities are described in Table 1.

Membership in the Development, Research, and Site Coordinator Teams was distinct, but the groups worked in a highly collaborative manner, with members joining the meetings of other groups to facilitate cross-team knowledge sharing. The Leadership Team was comprised of the project PI, co-PI, project manager, and lead members of the Development, Research, and Site Coordinator Teams.

Unless otherwise specified, the authors use the terms "the project team", "the project", "the team", and "we" to refer to the larger project-based team, including the Development, Research, Leadership, and Site Coordinator Teams. We use the term "project-based" to characterize these teams because they held broader project-level responsibilities that were not shared with the Educator Co-Developers, such as securing funding, project management, planning and implementing activities not directly related to the co-development activities (e.g., planning the pilot test of the completed professional learning course), and project reporting.

Table 1. Year 1 project responsibilities by group.

Group	Year 1 Project Responsibilities	<i>n</i>
Development Team (project based)	Led the development of the professional learning course. Worked with Site Coordinators to support and learn from the Educator Co-Developers. Had the primary responsibility for articulating the conceptual and pedagogical underpinnings of the PL.	6
Research Team (project based)	Provided formative feedback to the Development Team and Site Coordinators by conducting literature reviews, a needs assessment, and observations of the project and Educator Co-Developer activities.	3
Leadership Team (project based)	Provided strategic thinking and cross-team coordination and communication, particularly about the values and direction of the project. Members of the Research, Development, and Leadership Teams worked collaboratively to provide the direction for the project.	3
Site Coordinators (project based)	Recruited, supported, and learned from the Educator Co-Developers. Served as the primary liaison between the Educator Co-developers and the project-based teams.	5
Educator Co-Developers (a.k.a. case writers)	Developed place-based, data-rich lessons and used them with middle or high school students for the purpose of collecting information to write classroom narratives that served as one of the core components of the PLACES PL course.	21

3. Results and Discussion

When considering how to develop more equitable professional learning, our project team determined that we needed to use an equity lens across multiple aspects of our research and development work [10,22]. For our team, that meant adopting an intentional focus on equity in regard to the way we set priorities for the PL course, used equitable research practices to understand educators' needs, framed the work of engaging with data in the context of Earth Science education, engaged educators as collaborators in PL development, and designed professional learning that centers educators' experiences. Table 2 summarizes a few of the equity-focused practices our team employed and the tools and products we developed in the first year of our project. During Year 1, we: (a) conducted a needs assessment with educators to help guide the PL priorities, (b) articulated the conceptual and pedagogical frameworks for the PL, and (c) began working with educators to develop classroom narratives, known as "teaching cases," which are a core component of the PL model.

Table 2. Equity-focused practices and equity-focused tools related to Year 1 activities.

Year 1 Activities	Equity-Focused Practices	Equity-Focused Tools
Needs Assessment (Jan–May)	Conducted a needs assessment survey and focus group to center the voices of educators and guide PL priorities Used equity-focused data collection methods: peer interviewing, open-response questions, and asset-based survey items Used equity-focused analytical practices: valuing the breadth of individual experiences and reporting the findings using direct quotes	Asset-based survey items Peer-to-peer interview protocol
Guiding Frameworks for PL (Mar–Dec)	Articulated the conceptual and pedagogical frameworks for the PL: (a) a humanistic stance toward data and (b) a place-based approach to teaching and learning	Principles of place-based instruction for data-rich learning
PL Development (June–Dec and beyond)	Adopted the Making Sense of SCIENCE model of PL that uses classroom narratives, known as <i>teaching cases</i> , to center the voices of educators and their students Used a participatory design approach to center the voices of educators throughout the PL development process Used community-based recruitment and equity-focused tools to recruit Educator Co-Developers	Equity-focused recruitment goals Open-ended application item related to identity

In the sections that follow, we describe the Year 1 activities in detail, with emphasis on the decisions our team made around the equity-focused practices listed in Table 2.

3.1. Needs Assessment Survey and Focus Group

To design a PL course that builds on the strengths of and meets the needs of educators in the project's communities of interest, we conducted a national survey (the full instrument is available upon request from the authors) about teachers' experiences with data-rich, place-based Earth Science teaching and learning that makes use of technological resources ($N = 155$). We recruited Earth Science educators from in-school and out-of-school settings; teachers working with middle and high school students; and teachers who themselves represent, as well as work with, a variety of student populations, including recent immigrants and Indigenous youth. To gain a richer understanding of the survey responses, we conducted follow-up focus group interviews with 21 educators. We selected focus group participants from those who volunteered after participating in the online survey. We prioritized educators who reported working with recent immigrants or Indigenous youth because they were a primary focus of the professional learning that we wished to develop. The survey and the focus group interviews created space for teachers' voices to guide and prioritize the content and structure of the PL course.

Asset-Based Questions. Our survey questions and focus group protocols elicited respondents' descriptions of their own strengths, as well as their perceived needs. These instruments also prompted educators to describe the strengths their students bring to data-rich, place-based learning. Further, we invited the focus group participants to discuss the successes they have had in facilitating such learning. By asking questions like the ones in Figure 2, we positioned our team to work from an asset-based perspective rather than using a deficit model.

What strengths do you and your students bring to the task of using data in science teaching and learning?

As part of their science learning, do students have opportunities to explore connections to the places and communities around them (e.g., cultural, familial, historical, political, spiritual, economic, and scientific connections)? If so, what does that look like?

Figure 2. Asset-based survey questions.

Peer-to-Peer Interviews. During the online focus group interviews, our Research Team made efforts to disrupt the asymmetrical power relations inherent in focus groups and interviews [23] by using a peer-to-peer interview method in which pairs of participants convened in private breakout rooms to interview one another using a standardized set of prompts and without an external researcher to facilitate. Figure 3 shows the language we used to introduce the peer interview activity and one of the prompts used in the breakout rooms. We hypothesized that participants would feel more comfortable speaking openly with a fellow educator than with a member of the Research Team. However, after two focus group sessions, we ceased this method and opted for a more traditional researcher-led focus group. During the process, we observed that participants had difficulty managing dual roles as both peer interviewer and participant. We had difficulty promoting enough discussion to meet our focus group objectives: the respondents did not give elaborate answers, and the peer interviewers were not provided with adequate guidance to provide prompts for additional information.

Introductory Text from the Facilitator:

The structure of this focus group may be a bit new to some of you. We are going to send you into breakout rooms in pairs. You will have four opportunities to speak with the same partner. In each breakout session, you will be able to provide responses to specified prompts. We encourage you and your partner to take notes about the most important aspects of your conversations. However, we will also record the sessions in order to provide more detail and clarity when our team reviews your notes.

Interview Prompt:

Can you share an example of how you connected Earth Science learning to students' experiences in regard to their location, communities, and cultures? In what ways did data play a part, if any?

Figure 3. Introductory text and sample interview prompt used in peer-to-peer led focus group.

Although the researcher-led interviews succeeded in eliciting a wealth of information about teachers' existing practices and needs, our team still has much to learn about the potential of the peer-to-peer interview methodology as a more equitable research practice. When developing peer-to-peer interview protocols in the future, we will need to address questions such as the following:

- How can we frame the activity to support participants' understanding of the purpose and their roles as peer interviewers?
- What features of interview prompts or tasks invite high engagement in the peer-to-peer interview context?
- How can we structure the activity and note-taking process to elicit and document the depth of information required to meet the focus group objectives?
- On what basis should we pair participants to promote the most productive discourse?
- In what ways does the peer-to-peer interview process succeed in reducing asymmetrical power relations in the research process? In what ways does it fall short?

Equity-Focused Data Analysis. When analyzing and reporting the preliminary findings of the survey and focus group, the Research Team chose not to place sole emphasis on what "most" of the respondents needed (e.g., most frequently requested support, most common themes identified in open-ended responses). The Research Team *also* shared the breadth of the educators' needs and experiences by reporting the *unique* needs. We used direct quotes to share these individual experiences in the educators' own words. This approach to analysis reflects a belief that common themes and trends are important for setting priorities, but individual experiences and needs are also highly valuable, particularly when one of our primary purposes is to meet the needs of those who are often overlooked and underserved.

3.2. Guiding Frameworks for Professional Learning

To confront false beliefs about the inherent objectivity of science and data science, our project adopted a humanistic stance toward data and a place-based approach to data-rich learning. We employed these stances as guiding frameworks for the professional learning course, for example, in determining what was included, how it was designed, and how it was delivered.

Humanistic Stance Toward Data. A humanistic stance to data-rich learning [11] foregrounds the human dimensions of learner engagement with data, such as personal experiences, cultural practices, and sociopolitical contexts. By taking this approach, our project has the potential to create more equitable opportunities for data-rich learning by acknowledging the human decisions (and biases) that undergird data collection, inter-

pretation, and use, thereby counteracting the idea that data are inherently objective. By humanizing data, our PL invites educators (and, ultimately, their students) to directly examine the typically unnamed sociocultural inputs and outputs that permeate all aspects of data. Such a humanistic approach also creates space for learner agency by embracing learners' "personal and direct experiences with data, measurement, and the contexts in which data are collected" [11] (p. 665), as resources for their work with data.

Place-Based Approach to Data-Rich Learning. From the outset of the project, our team has embraced a place-based approach to learning. This approach centers learning on students' lived experiences and ways of knowing, as well as the local context, that is, the physical landscape and "the cultural, historic, and socioeconomic meanings of places" [24] (p. 151). This approach puts learners at the center of learning by acknowledging and amplifying their funds of knowledge [25].

Our team drafted a guiding document called the "Principles for Place-Based Learning for Data-Rich Instruction" to further articulate our project's humanistic stance and place-based approach to teaching and learning. (See Figure 4 for sample principles.) This document was informed by the needs assessment and insights from the Co-Developer Educators who spoke to our team about their place-based practices. Our team used this guide as a project touchstone to guide decision-making in multiple aspects of the project work, including PL development, research, and dissemination. One of our Co-Developer Educators shared that they were inspired by this guiding document to learn more about how to meet the needs of *all* of their students as they engage with data:

- | |
|--|
| <ol style="list-style-type: none"> 1. Place-based learning honors multiple ways of knowing and conducting science. Place-based approaches recognize the value of various types of data describing the world around us. The learning may draw upon and affirm aspects of the learners' identity and sense of place, whether cultural or geographic. It may include learning about other cultures and identities, and incorporating varied resources that connect to those places (e.g., elder experiences, oral histories). 2. Place-based learning promotes community involvement and learner agency in data use. Learning that supports collaboration with community members to pose questions and address local concerns using data can provide motivation and confidence for learners to learn and participate in science. 3. Place-based learning uncovers inequities and addresses injustices using data. When centering equity, data-rich experiences that use place-based approaches can promote greater awareness of social, economic, and environmental injustices, and provide learners with the tools to explore and address the injustices they uncover. |
|--|

Figure 4. Samples of the principles for place-based learning for data-rich instruction.

I want to dive into Principle 1 more and how I can better support my culturally and linguistically diverse learners. I also want to look at my LGBTQ+ students and make sure that they feel supported and have data choices. (Co-Developer feedback, October 2022)

3.3. Professional Learning Development

The project team engaged educators as co-developers, alongside project-based developers to create a new PL course that follows the Making Sense of SCIENCE (MSS) approach to science professional learning. MSS is a program that offers a well-established model for teacher professional learning that has a proven track record of strengthening teacher knowledge, transforming classroom practices [26], and increasing student achievements in science, particularly for low-performing students, English learners, and those with poor literacy skills [27]. MSS offers a suite of professional learning courses covering topics in earth, life, and physical science for K–12 teachers (e.g., energy, organisms), which have been used in more than 20 states, reaching thousands of teachers. To help the reader better understand the role of these Educator Co-Developers in the current project, we first describe an essential component of the Making Sense of SCIENCE approach: teaching cases.

Teaching Cases. Making Sense of SCIENCE courses are designed around teaching cases of practice that draw from the authentic experiences of educators [27]. Each teaching case is written as a narrative story that a teacher shares about what happens in their classroom. In the PLACES professional learning course, teaching cases are used to highlight common challenges faced in data-rich teaching and learning, to present a variety of student ideas and approaches to working with data, and to surface teachers' pedagogical reasoning. Teaching cases are used in the full context of the PL as tools to help educators critically examine what might happen in a real classroom, engage in evidence-based discussions about student thinking, and consider the tradeoffs of various instructional choices.

The use of educator-developed teaching cases in professional learning shifts the locus of expertise away from PL developers; this method reifies the notion that educator experiences and students' ideas and ways of knowing are valued and worthy of learning from. By presenting a diverse series of cases that articulate the salient and relevant cultural, historical, and sociopolitical contexts in which the teaching and learning occurs, the PL course provides windows into a range of experiences and invites PL participants to consider how these factors may shape the learning in their own classrooms.

Participatory Design of Teaching Cases. The project team recruited a group of 21 Educator Co-Developers, known as Case Writers, who worked with project staff to plan and then use data-rich, place-based Earth Science lessons with their students. From these lessons, Case Writers collected samples of student dialogue, videos of learner interactions with data tools, samples of student work, and their own reflections about their instructional choices. The Case Writers then worked closely with project staff to create a draft narrative story. These drafts will be compiled, edited, and formatted by Development Team staff for use in PL with other science educators (at the time of writing, midway through the project, case drafts are still being compiled and edited) (see Figure 5).

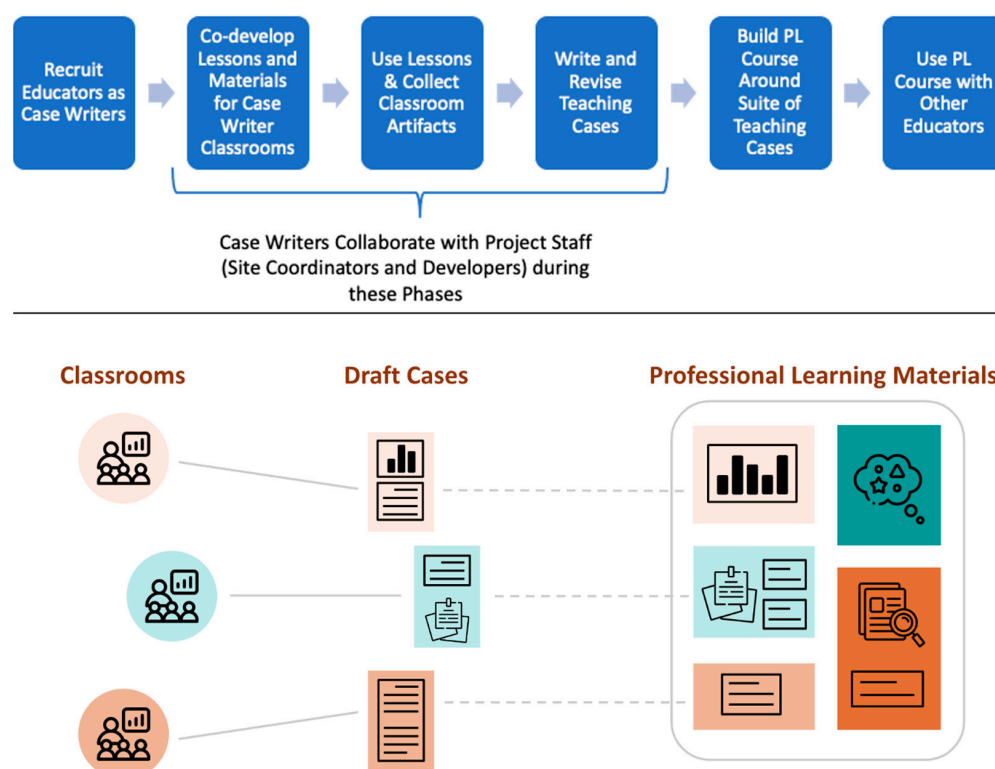


Figure 5. The professional learning course development process.

By engaging educators in the participatory design [28,29] of their teaching cases, we provided an opportunity for educators' perspectives to shape the PL throughout the design process, not just via a needs assessment or during reviews of the final PL course.

By privileging educators' expertise and ways of knowing, we see participatory design as a vehicle for acknowledging and repairing the rifts in epistemic authority that have traditionally posed a tension between dominant and non-dominant communities [30].

Our approach to professional learning shares features with models of *local* PL that center teacher and student experiences, such as lesson study [31–33] and professional learning communities [34]. However, because the PLACES PL will be disseminated nationally, our model allows a much wider range of teachers to learn from the diverse experiences of our team of Educator Co-Designers.

The Case Writers were supported in doing their work through a series of project-led workshops from June 2022 through April 2023. These meetings served as a space for balancing educators' voices with project-led guidance.

Initially, the Case Writers wanted to ensure that their narratives conformed to the project's expectations. They asked numerous questions about the structure of cases, quality and types of data-lessons desired by the project, and types of student work samples that could support teacher discussions during the PL. Holding fast to the desire to center educators' voices, the Development Team attempted to provide direction to the Case Writers without stifling the opportunity to learn from them. The Development Team shared and discussed the guiding frameworks and samples of teaching cases from prior PL courses, but also emphasized the importance of the educators' own experiences.

The Case Writer feedback demonstrated that educators did eventually see teaching cases as spaces for bringing their authentic voices forward and showed that educators felt they had the agency to determine the content of their cases. One Case Writer alluded to the authenticity of the cases, as they commented on the conversational style of the teaching cases:

The length and style of how the written portion would look like [in the sample case]. I like that it is much more conversation based—like I would just be chatting to another teacher next to me. (Case Writer feedback, 8 February 2023)

A different Case Writer indicated that they saw themselves as having the authority to tell their own story:

Case writing is really open ended for me to share my story. (Case Writer feedback, 7 February 2023)

Because this work is still in progress, it remains to be seen whether and in what ways educators' voices are truly centered in the final teaching cases. As a future step, teaching case drafts will undergo a process of winnowing and editing, known as "case shaping." The responsibility and final authority for the case shaping lies with the project-based Development Team. One of the equity challenges will be to find a balance among a large number of competing priorities, while honoring the contributions of the Case Writers. For example, the Development Team must ensure that the funder's requirements are met, construct a coherent PL experience that fits within the allotted time frame, ensure that the PL follows guidelines from our Indigenous partners, and ensure that the requests we make of the Case Writers are commensurate with the stipends that they receive.

In anticipation of these challenges, we laid out a plan to help the Development Team navigate this balancing act with sensitivity, care, and respect. First, we were transparent about the process. We told the Case Writers well in advance that case shaping would take place, described the types of transformations that might happen with their writing, and invited them to participate in the shaping of a case. Second, we encouraged the Case Writers to name two or three of the most important things they want their case to communicate, so that the Development Team could honor those requests. Third, we offered the Case Writers the option of working closely with the Development Team in a longer editing process to ensure that their stories are represented in ways that are acceptable. Fourth, we called on the Site Coordinators—who had worked in close proximity with the Case Writers, including co-planning lessons and making classroom observations—to review the edits, with the goal of maintaining the integrity of the case-shaping process even after the Case Writers had completed their contributions. Finally, in accordance with several of our Memoranda of

Understanding, the cases developed in and with Indigenous communities will be submitted to their respective tribal councils for review prior to their broader use (at the time of writing, the teaching cases that were co-developed with Indigenous communities are still being edited and, thus, have not yet been submitted for review by their respective tribal councils).

Community-Based Collaborative Recruitment. As described previously (see Table 1), the project team includes five regional Site Coordinators (i.e., science leaders located across the U.S.), whose primary role is to recruit and work with the Case Writers in their geographic regions. This demarcation of roles allowed for community-based recruitment in which the Site Coordinators drew on their longstanding relationships with local educators to identify potential applicants and provided the project team with context-specific feedback on the recruitment efforts. For example, upon the advice of one Site Coordinator who had extensive experience working with Indigenous communities in her area, we revised our recruitment flyer. An early draft read, “Looking for innovative and reflective educators!” but the Site Coordinator commented,

I know this may sound odd, but many educators that we would want to be involved [as Case Writers] do not necessarily consider themselves innovative and reflective educators. In Indigenous cultures, I have understood that it is not a great thing to toot your own horn. (Internal Comments on Recruitment Flyer, 13 April 2022)

To center the voices of the community members most impacted by the work, we revised the text to say, “Looking for educators who teach Earth Science topics in grades 6–12 to be partners in writing teaching cases for use in professional learning!” Throughout the recruitment and development process, the local and cultural knowledge shared by Site Coordinators has been vital to our approach.

Equity-Focused Recruitment Tools. To set meaningful equity goals and to hold ourselves accountable, we created a recruitment table that specified: (a) the requirements for each *individual* Case Writer participant, (b) the desired characteristics for the *group of educators*, and (c) the desired characteristics for the *group of schools/sites* (see Table 3). We structured the table to ensure we recruited educators who work with the youth populations of interest, and educators who, themselves, reflect these populations. To track our progress toward these goals, we asked applicants to complete a short form with demographic identifiers and an optional question, “What other descriptors or personal characteristics would you like us to know about?” Their responses reflected nuances of identity that we would not have been able to capture through selected-response questions alone. A few of the Case Writers’ responses follow:

Table 3. Case writer recruitment goals.

Total Number of Educators	Individual Inclusion and Exclusion Criteria (True for Each Case Writer)	% or # of Educators by Sample Characteristics (Across the Group)
12–18 Across 5 National Sites	<u>Inclusion</u>	<u>Personal Characteristics</u>
	Will teach middle or high school students any Earth Science topics (either school-based or out-of-school contexts) in 2022–2023 school year	Two or more educators who themselves immigrated to the U.S. (born outside of the U.S.)
	Has a high degree of experience with data-rich teaching and learning in Earth Science	Two or more educators who identify as Indigenous
	Is interested in learning more about how to support data fluency by using a place-based approach to teaching and learning	Four or more educators with prior experience using data in instruction
	Is able to integrate data into teaching (e.g., access to technology or other)	Four or more educators who have prior experience with place-based learning
	Can obtain district/site approval for participation	<u>School/Site Characteristics</u>
	<u>Exclusion</u>	Three educators per site
	We do not have any specific exclusion criteria	Two or more educators from an informal learning space (out-of-school time)
		Six or more educators who are currently working with students who are Indigenous or recent immigrants
		At least 50% middle school educators

While I identify as Chicano, I feel very closely connected to the Indigenous people of [my area]. My parents always raised us with very close relationships with the Native

American people in the state and we share the same ancestors. (Application Form, Case Writer A)

I work with Hopi students, kindergarten to 6th grade, who reside on our native lands in a remote location in [location redacted]. One of my driving goals and life work is to provide my students with experiences that honor and celebrate our history, philosophy, and knowledge; to instill in my students that our people were scientists whose discoveries allowed our people to prosper in a challenging environment. This requires that I have to create these lessons, cultivate partnerships with our local community members and persuade our local leadership that this is a powerful way of increasing “test scores.” I am dedicated and determined that my children have equal opportunities to enhance their knowledge so that we may continue to live in the land of our ancestors. (Application Form, Case Writer B)

I am committed to creating a science program for our students that is place-based, focused on analyzing and collecting data to add to the traditional knowledge base that my students and their community have about their ancestral territory. Also, to assist in furthering students’ connection to their land and to foster stewardship of their land. (Application Form, Case Writer C)

While our project intentionally sought to support students and educators from Indigenous and recent immigrant communities, we recognize that applicants are whole beings with intersecting identities that are poorly represented on standardized survey forms. There are many aspects to an individual’s identity that a person might want to share or consider relevant to the project. Responses to this open-ended question helped our team select Case Writers according to factors that were salient to the applicants.

3.4. Key Findings and Discussion

3.4.1. Equity-Focused Tools Supported the Articulation of Shared Values, Transparency, and Accountability, and We Have More to Learn

The explicitness of our project’s guiding frameworks (Table 2) and recruitment goals (Table 3) allowed our team to achieve more equitable participation and transparency in decision-making. This was key, as the work of developing professional learning involves making innumerable choices. Such frameworks and recruitment goals provided concrete tools for weighing the tradeoffs of various choices, holding ourselves accountable to our stated values and goals, and communicating the rationale behind our decisions with other members of our team, as well as with external parties.

Inspired, in part, by the concept of a motivational touchstone described by We All Count’s Data Equity Framework [10], we have embraced the practice of collaboratively creating and widely sharing documents that explicitly identify our project goals, values, priorities, and beliefs. To create these documents, we surfaced and acknowledged our individual goals, values, priorities, and beliefs, and then engaged in cycles of discussion across various teams to come to a consensus about the project’s stances. In addition, we consider these tools to be living documents that can be (and are) revised over the life of the project. In this way, we make space to continue learning and to account for the needs that arise.

Although the first drafts of these guiding documents were created using information gathered from the needs assessment participants and with input from our Case Writers, we missed the opportunity to co-create or elicit feedback from educators when developing the “Principles of Place-Based Instruction for Data-Rich Learning.” More generally, our project strives to do a better job of consistently and strategically engaging interested parties *outside of the project-based teams*. A key takeaway is that active transparency and accountability requires that we: (a) incrementally share progress and information with researchers across a wider variety of contexts, community members, transdisciplinary holders of experience and expertise to check our assumptions, (b) reveal our biases and blind spots, and (c) expand our understanding of what this work can look and feel like.

3.4.2. Research Practices Centered Educators' Voices, and We Have More to Learn

One important step to centering someone's voice is to ensure that their humanity and individuality are not removed. Too often, research "best practices" mean asking individuals to identify themselves according to a series of predetermined checkboxes; collapsing categories of participants, thus relegating the groups with the fewest members to the category of "other"; and "protecting human subjects" by removing names and only reporting trends and themes. These practices may be especially harmful to those individuals and communities who have already been minoritized.

In concert with our humanistic stance toward data for the PL, our project succeeded in humanizing our project data by inviting participants to describe themselves using their own words, valuing individuals' experiences by reporting small numbers, and reporting educators' responses using direct quotes.

One tension that continues to exist in our effort to center participants' voices in a research context is the balance between honoring a participant's individuality and humanity, while also ensuring that privacy and confidentiality are appropriately protected. For example, we have more to learn about how and when pseudonyms are or are not appropriate, and how to engage participants in pseudonyms that reflect characteristics that they feel are important for sharing their stories.

Our team is thinking about reaching out to our participants to ask about what pseudonyms they'd like us to use, if any. Do any of you have words of wisdom about how to structure that [request]? Specifically, I'm thinking about a wide variety of choices that our team and the participants would need to make, including whether and how to invite honorifics, first names, and/or last names; how we can help folks consider the ways names might reflect characteristics such as age, gender, ethnicity, etc.; and whether folks do or do not wish to use a pseudonym at all. "Within indigenous research, presenting pseudonymized individual voices can be entirely inappropriate." (Allen and Wiles, 2015, p.4) [35] (Project Communication, Research Team Member, 2 December 2022)

Our asset-based approach to needs assessment questions successfully centered educators' voices in the prioritization of PL needs by surfacing some of the strengths that teachers and students brought to the work concerning place-based, data-rich learning. When we began this project, we referred to our survey and focus group as a "needs assessment." While conducting this self-reflective analysis, we began to wonder whether there was a different phrase that could describe our asset-based approach. We found the term *appreciative inquiry*, which the NORC Walsh Center for Rural Health Analysis [36] defines as a process that focuses on identifying the assets, strengths, and successes in people and communities to bring about positive change, while simultaneously identifying needs. Appreciative inquiry [37] is a methodology for organizational development with roots in the fields of organizational behavior and positive psychology. This process encourages organizations to shift away from deficit models of change, and instead study the best aspects of an organization and then use that positive core as the basis for envisioning its future. Now that our team has "discovered" this process that is so well aligned with our equity goals, we anticipate using appreciative inquiry in our future work.

3.4.3. Development Practices Centered Educators' Voices, and We Have More to Learn

We successfully recruited a large cohort of Case Writers, who have shared their experiences with each other and with our project team through a variety of synchronous and asynchronous modes, including office hours, small group and one-on-one consultations, exit surveys, audio or video recordings, emails, and shared annotated documents. From these shared experiences, our project team has documented Case Writers' interests, as well as the datasets, phenomena, and topics they found most relevant to data-rich teaching and learning. In this way, the lived experiences of Case Writers are guiding many of the design choices for developing the PL course beyond just the teaching cases. Case Writers and their collaborating Site Coordinators continue to shape the work as they implement place-based,

data-rich lessons with their students. Given that the majority of Case Writers and Site Coordinators expressed an interest in continuing their participation, we are actively seeking ways to compensate and support their ongoing work to ensure that these valuable voices continue to inform and shape professional learning over the long term.

Throughout this work, our external evaluation team has provided key support to help us stay the course as we try out (and learn from) equity-focused practices. They have held a mirror up to our process, provided feedback about the nature of our collaborations, and offered sage recommendations that inform our efforts. Their stance as an honest and reliably critical friend has pushed us to notice and listen, as well as to stretch and try new things. A few months ago, they made this recommendation to the project team:

Consider ways to understand the assets and perspectives of Indigenous and recent immigrant populations, as well as the challenges and barriers they face within education. For instance, invite Case Writers who are Indigenous or immigrants to share their classroom experiences with the PLACES community.

This recommendation highlights that our work is not done. In fact, we believe that the true nature of our collaboration between Case Writers and the Development Team remains to be seen. As we move forward into the next steps (i.e., continued case shaping), we must take care that Case Writer contributions do not become superficial, and that developers and researchers do not overrun or co-opt the voices of educators or their students.

Thus far, we have observed a strong interest among Case Writers for the PL to center both humanizing and place-based approaches in teaching and learning with middle and high school students. However, a clear and imperative next step toward more equitable professional learning is to fully articulate how we will *explicitly* support equity within the PL course. We acknowledge that teachers' dispositions toward equity-focused work [38,39], teachers' competencies related to culturally responsive teaching and equity [40], and substantive consideration of racism in both science teaching and learning [8] and science PL [18] are vital in supporting minoritized learners' success.

4. Reflections and Significance

We have described research and development processes that we believe will help shift the conversation around whose knowledge, experiences, and ways of knowing are valued and validated in science PL and the classroom. We believe that coming to a shared understanding of and articulating our project values around equity has helped ensure that our processes and products are consistent with our goals. Yet, we acknowledge that we are merely at the beginning of a longer journey.

We have learned that this work is hard. Many of the structures tied to traditional research and development processes are not designed to easily facilitate collaboration across numerous groups in these ways. Collaboration, reflection, and iteration are time-intensive processes that demand a culture of trust and care across all participants. Those with more power and privilege must actively work to avoid asserting it over the group and embrace a flat structure of shared leadership. It necessitates vulnerability, shifting our roles from "experts" towards partners, maintaining a curious stance to pursue new understandings from those around us, and grace in recognizing that while we might "just try," we might end up discovering we are trying in the wrong ways. It also requires tools and mechanisms to call individuals (or the group) back to our shared goals and beliefs. This is especially apropos when one or more members (or the product of the work) fail to align with the vision set by the larger community. This crucial work often happens outside or in addition to milestones and deliverables outlined by funders. Yet, this simply should not be.

Despite these challenges, we are inspired by the fact that many of the equity-focused practices and tools that we describe in this analysis are not entirely new to members of our team. Rather, they reflect our pre-existing underlying beliefs about the value of teachers' (and their students') perspectives. We are thankful for the opportunity to document and reflect on the ways our practices have centered the voices of educators. Taking the time to document our efforts to embed equity throughout our work has helped our team slow

down to appreciate the deliberate steps we have already taken. The act of writing and reflecting has re-energized us to grow in areas where we have identified gaps. In the spirit of continued reflection, we invite readers to contact the authors to share critiques, help us identify missed opportunities, and share related experiences.

As a precursor to this work, the Making Sense of SCIENCE project has a long, successful history of working with teachers to develop highly effective PL in science. Prior research has focused on the impact of case-based PL courses on teacher knowledge, classroom practices, and student knowledge [27,41,42]. This current work represents our first attempts to document and explicate our strategies for addressing systemic inequities in science education through a *design process* that centers the experiences of marginalized teachers, students, and their communities. In documenting the process and sharing practical tools, insights, and lessons learned from our efforts thus far, we hope to invite conversations with other researchers and developers about practical efforts to center historically unheard voices in science PL.

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