

# Cultivating Teacher Efficacy for Social Justice in Science



BY LIBBY GERARD, ALLISON BRADFORD,  
ANGELA DEBARGER, KORAH WILEY,  
AND MARCIA C. LINN

**T**wo teachers—whose students were concerned about environmental injustices in their communities and eager to take action—initiated a collaboration to design freely available, customizable curriculum materials and a model professional development workshop. The workshop was designed to foster teacher efficacy in incorporating social justice into science teaching. To cultivate teacher efficacy, the materials were created to respond to middle school science teachers’ concerns about supporting students’ emotions around social justice issues and empowering students to take action.

Our collaboration, Anti-Racism Interactive Science Education (ARISE), between middle school teachers, education and equity researchers, and curriculum designers, created units that could be adapted for each student and community. ARISE sought activities where students could discuss connections among core science ideas, local social justice issues, and their personal and cultural experiences.

## Curriculum Materials

ARISE designed and tested units on three topics aligned with the *Next Generation Science Standards* (NGSS Lead States 2013), as described in Table 1. Teachers approached us with ideas for the initial versions of the units, and together we designed them so they could be adapted to other student populations and communities. For example, the

initial teachers wanted their students to explore the impact of combustion reactions studied in chemistry by examining particulate matter pollution produced by these reactions in a local refinery. This unit empowered students to collaboratively explore the factors that lead to social inequities in asthma rates and generate actions for bringing about societal change. Teachers incorporated interactive maps that displayed distributions of particulate matter and incidence of asthma in the communities served by the schools (see Figure 1).

The units are implemented using the Web-Based Inquiry Science Environment (WISE) and are freely available Open Educational Resources (OERs) including the data and data visualization tools (see

Table 1 and Figure 1; also, see note at end of article). Units are freely available and customizable (see link to WISE units under Online Resource). Knowledge integration (Linn and Slotta 2000) and justice-centered science pedagogy (Morales-Doyle 2017) guided the curriculum design. Knowledge integration is a constructivist framework that aligns with the 5E instructional model and emphasizes eliciting learners' ideas.

To support teachers who are new to teaching social justice in science to develop their efficacy and enable customization of the units, ARISE created workshops. At the workshops, teachers could localize one of the pilot-tested units for their students rather than creating units from scratch.

**TABLE 1: ARISE units, NGSS standards alignment and description.**

Unit	NGSS standards	Description
<b>COVID-19 Data Science and Equity</b>	MS-ETS1-2 MS-ETS1-3	Students explore the various ways data are used to communicate scientific information to the public and make policy decisions. Students practice making graphs and analyzing data related to COVID-19 and analyze the ways in which the COVID-19 pandemic, social issues, and health inequities have affected different communities. Students, for example, graph the relationships between factors such as employment as a frontline worker, availability of health services in the neighborhood, and COVID-19 infections.
<b>Chemical Reactions and Asthma</b>	MS-PS1-1 MS-PS1-3 MS-PS1-4 MS-PS1-5 MS-ESS3-3 MS-ESS3-5	Using computer models and drawings, students investigate greenhouse gas emissions and their effects on climate change and air quality. The unit introduces redlining and enables students to explore why people of color are more likely to live in an area impacted by air quality and climate change due to historical housing policies. Students use a virtual experiment to investigate alternative fuel solutions and their impact on greenhouse gas emissions and global temperature. Throughout the project students gather examples they can use to compose an evidence-rich letter to a local politician on how gasoline combustion impacts climate and health, and what they could do to take action.
<b>Global Climate Change and Urban Heat Islands</b>	MS-ESS3-3 MS-ESS3-5 MS-PS3-3	Students explore how solar radiation from the sun warms the Earth, and how greenhouse gases impact that energy cycle. They use an interactive model to investigate how human activities contribute to the greenhouse effect. Next, students investigate global climate change and identify the inequitable impacts of Urban Heat Islands caused by rising global temperatures. The unit culminates with students designing their own Climate Action Plan.

## Designing a workshop model

Workshops that promote science teacher efficacy for teaching social justice augment the limited course-work and textbook resources addressing cultural diversity and racial biases in teacher education programs (Sleeter 2017). Typical science textbooks neglect social justice and race, due in part to their exclusion from the national science standards (Rodriguez 2015). Further, middle school science teachers, who mostly (80%) identify as White, value supports for guiding their students—over half of which identify as Black, Latinx, Asian, or American Indian (National Center for Education Statistics 2018).

To develop strategies for promoting teacher efficacy, ARISE developed a workshop that featured three promising strategies (Donohoo, Hattie, and Eels 2018). ARISE tested the strategies with all collaborators, as well as with 12 new teachers from four different schools. The strategies enable teachers with differing levels of self-efficacy to support each other. These strategies could also be incorporated into other professional development programs. The tested strategies are:

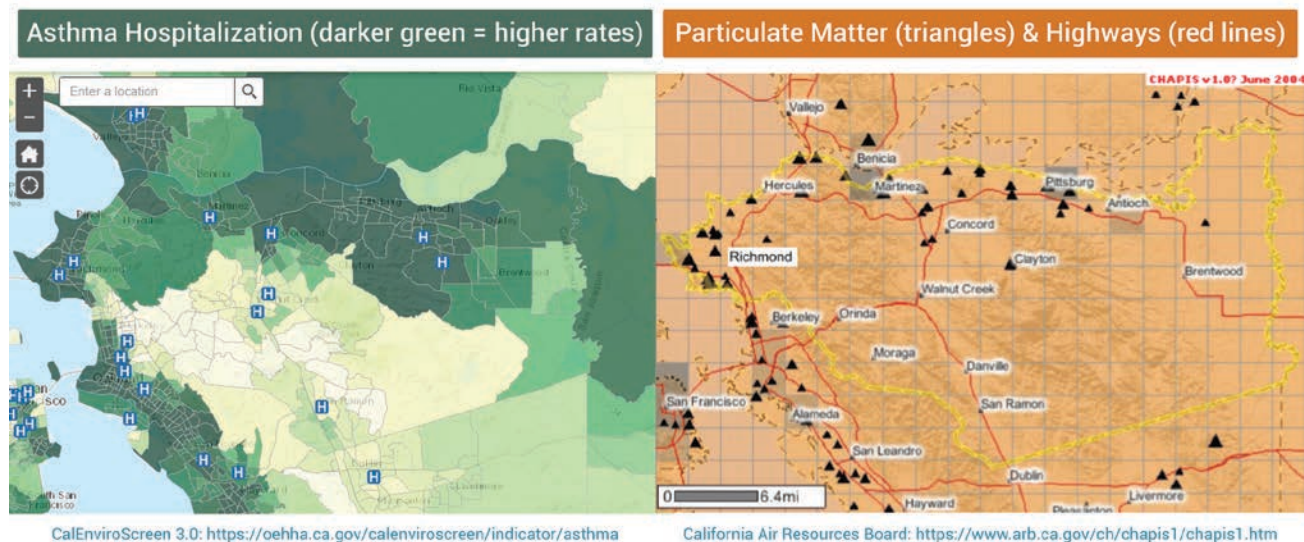
- Positioning. Developing a position about teaching social justice in science, including developing trust with one another and co-constructing criteria for effective instruction.
- Envisioning. Role-playing classroom enactment to envision student reactions with trusted partners who have unique classroom experiences. Teachers explored dilemmas such as how to discuss emotional issues in the science classroom.
- Customizing. Localizing pilot-tested activities to class curriculum and student lived experience.

These strategies foster collective efficacy by creating shared goals, helping each other anticipate student reactions, and jointly customizing units.

### Positioning

The positioning activity, led by one of the experts in social justice, engaged all the collaborators in building collective and personal efficacy. Initially, each participant expressed their ideas anonymously in a Padlet and then joined a collective effort to integrate

**FIGURE 1:** ARISE Asthma unit. Interactive maps display the rate of pollution and incidence of asthma in the communities served by the schools; unit empowers students to collaboratively explore the factors that lead to social inequities in asthma rates and generate actions leading to societal change.



their ideas about teaching for social justice (see Table 2). The anonymous Padlet entries ensured that each participants’ voice was heard, ideas were shared simultaneously, and participants could comment on another’s ideas without connecting a person’s status to their response.

To deepen their thinking, participants interpreted a graph of COVID-19 hospitalization rates by race and ethnicity (see Table 2). The graph showed significantly higher COVID-19 rates for people of color compared with the White population. The facilitator used a knowledge integration approach to elicit ideas about why these disparities occurred and to

identify the information participants used to inform their perspective (Linn and Slotta 2000). Participants recorded their ideas in the Padlet, reviewed each other’s ideas, and discovered an idea different from their own. The facilitator prompted participants to reflect on the criteria they used when reviewing others’ ideas. Participants distinguished among criteria they might use to consider the views of others. They then reflected on the support they, or their students, would need to engage in discussion of social justice issues with peers in the science classroom. They also identified strategies for garnering support from parents and school authorities.

**TABLE 2:** Collaborative positioning activity modeled on knowledge integration.

Knowledge integration process	Prompt: Sample partner responses
Elicit ideas	What do you think might be the reason for this disparity shown in the graph? What information are you drawing on to inform that perspective—how have your life experiences shaped your perspective and the information that was available to you to interpret this disparity? <ul style="list-style-type: none"> <li>• “Family experiences”</li> <li>• “I grew up in a marginalized community of color”</li> <li>• “News reports”</li> </ul>
Discover new ideas	Review other people’s posts. Do you see any new perspectives, or new pieces of information, different from your own? In light of these perspectives, what information can you share that supports someone’s view or provides an alternative to someone’s view? Respond to another’s post. <ul style="list-style-type: none"> <li>• “I see this reflected in my own personal experiences and circles”</li> <li>• “I agree and want to think more about how racism shows up across systems—healthcare, housing, education”</li> </ul>
Distinguish ideas	What makes you more or less likely to accept and incorporate a new idea from someone else, into your perspective? <ul style="list-style-type: none"> <li>• “It’s backed by personal experience or data”</li> <li>• “Close to my thinking, or a very stark contrast that compels me to think”</li> <li>• “Trust”</li> <li>• “It’s from someone in my community”</li> </ul>
Reflect and connect	What support do you feel like you, and your students, might need to engage in social justice issues in science class? <ul style="list-style-type: none"> <li>• “I’d like access to other perspectives, different from my own”</li> <li>• “I would also like to know more about my students, including their families to know where to begin the conversation”</li> </ul>

The positioning activity welcomed each individual's moral and ethical stance. It expanded the perspectives each participant considered and affirmed the variety of ideas held by the partners. It fostered collective identity as a team of educators who *can and do* teach social justice as a key part of teaching science.

To further foster a sense of interdependence among participants, each partner was guided to generate individual goals for teaching social justice in science using Jamboard (see Figure 2). Next, in small groups, partners reviewed the posted goals and jointly categorized them into themes to represent shared commitments. These shared goals were revisited throughout the workshop.



### Envisioning

In the envisioning activity, teams of three to four teachers from different schools imagined how the unit they planned to teach would play out in the classroom and determined possible instructional moves. Each team

member reviewed the lessons from the perspective of one of their students. They discussed issues such as what may be uncomfortable or new for their teaching. They also identified which resources could be helpful, such as connecting with the school counselor to assist in facilitating small-group discussions.

**FIGURE 2:** Snapshot of a Jamboard being created in the workshop. Each sticky note captures a response of a teacher to the questions: Why is it important to you as a science teacher to address issues of inequity? What are your goals for bringing social justice into your science classroom?



For example, one team of four seventh-grade teachers from three different schools focused on the Chemical Reactions & Asthma unit. The teachers jointly grappled with potential challenges they might encounter when launching a discussion of redlining. Redlining refers to the discriminatory, historical practice of banks using maps that indicated the “safety” of granting loans in particular neighborhoods. Black, immigrant, and low-income neighborhoods were often labeled as hazardous and outlined in red (hence the term *redlining*). This fueled a cycle of disinvestment and segregation that has contributed to these neighborhoods having lower air quality and higher rates of asthma today. Teacher A was concerned that their students might not see the relevance of redlining and asthma to their lives. Teachers B and C suggested alternative ideas that enabled the first teacher to reconsider the relevance of discussing redlining.

Teacher A: Our community, this [redlining] may not relate to our students.

Teacher B: I’d push back on that. I’d say that where they live in the community is a result of redlining.

Teacher C: It’s just the reverse, right?

Another team grappled with possible responses, while role-playing potentially emotional student discussions. One teacher remarked, “I want to give students a way of taking personal control over their health . . . let them know that just because you have a condition you can do something.” One teacher expressed concern, saying, “We don’t typically have emotional conversations in science.” Another recalled redirecting conversations about emotional issues toward empowering students by asking students to “Focus on what you think you can do to make a difference.” Another suggested an alterna-

**TABLE 3:** Example seventh-grade student reflections at the end of the Chemical Reactions & Asthma unit.

<b><i>Do you think the impacts of air pollution are different depending on where you live?</i></b>	<b><i>What are some ideas you have for policies or actions that make sure some communities do not experience more harmful impacts than others?</i></b>
Some people that live near freeways, they have it worse because they can get sick from all of the gas that is going in the air. Also because of history it’s affecting more African American people.	We could start off by getting rid of gasoline and moving people away from freeways and factories so we can help them not become sick.
The impacts are different depending on where you live because people in poorer places are closer to freeways and refineries which produce lots of pollution which can negatively impact people in those areas. For many years, people in “redlined” areas were not allowed access to mortgages and other credit, causing a cycle of disinvestment. Even though doing these practices are illegal today, the effects still linger.	I think that people who are a genuine big part of the community should be the one responsible with actions like that because somebody like that would need to know fully well how it would impact people. Also a person who is a part of the community will most likely not have a bias that puts money ahead of lives.
Impacts are very different depending on where you live because living closer to refineries or highways cause higher impact, but you could also live in a place that is poor and low funded which could make it hard to leave places with higher exposure to pollution.	First have inspections that regulate how much pollutants that come out of refineries and if they exceed a certain point tell them they need a way to stop producing that much pollution.

tive way to redirect emotional energy by suggesting, “We could have each student write their ideas for 30 seconds first. Then, share.”

Connecting this new dilemma to their existing pedagogy helped teachers realize that they are efficacious in their science teaching. Envisioning students’ ideas surfaced each teachers’ existing strategies for guiding student learning, reflecting their deep knowledge of their students’ cultural and science ideas. They helped each other adapt tested strategies to teach social justice in science.

## Customizing

The workshop empowered teams to customize the pilot units to align with their curriculum and connect to their students’ anticipated ideas. The Curriculum Visualizer (see Figure 3) made the pilot unit and its underlying pedagogy visible to the teachers. The Visualizer is a Google Slides representation of the unit where each activity is on a slide and color-coded by the pedagogical approach intended for the activity. This makes it easy for designers to add, delete, or rearrange activities in the unit, while considerate of pedagogical implications. The teams used the Visualizer to create adaptations for the unit that they planned to implement. By aligning the custom-

izations with the pedagogy behind the unit design, teachers deepened their understanding of strategies for facilitating inquiry (Tekkumru-Kisa, Stein, and Doyle 2020).

This shared representation gave teachers the ability to focus on the specific details of one activity as well as to view the composition of the unit as a whole. For example, using the Visualizer, Teacher A recognized the importance of distinguishing biological from environmental impacts on asthma. Teachers B and C elaborated.

Teacher A: In the data table in 4.6, students may say it could be due to biological effects. I am trying to tie the asthma rate data to the refinery in [local city] instead . . . I think it would be more convincing to show asthma rate data from another city that does not have a refinery in comparison to this.

Teacher B: But it’s not only the refinery. It’s the compounding of pollutants in the air. What might be other sources that contribute to the asthma rate?

Partner C: It is also not only if people have asthma, but it’s about the management of asthma. This data shows emergency department visits. It’s whether their asthma can be kept under control to prevent visiting the hospital.



**FIGURE 3:** Curriculum Visualizer. Each activity in the lesson has a separate slide, making it easy to rearrange the sequence or to add new activities. Slides are color-coded for the knowledge integration process they represent. A black slide is used to indicate a new lesson. A slide at the end of each lesson provides sample student responses (collected from pilot studies) to an embedded assessment to support teachers in personalizing the unit to their students' ways of thinking.

The screenshot shows a presentation slide titled "4.6 Asthma Rate Data" under the heading "KI Process: Discover Ideas". The slide content includes a text description of comparing asthma rates in Richmond to Contra Costa, a bar chart showing hospitalization rates per 10,000 people, and a list of customization ideas. A comment box on the right shows a discussion about the biological explanation for the disparity. A legend in the bottom right corner defines the color-coding: Elicit Ideas (pink), Discover Ideas (orange), Distinguish Ideas (green), and Reflect + Connect Ideas (blue). Annotations with callouts point to various elements: "Slides represent activities in unit" points to the slide thumbnails on the left; "Comments recorded by partners in workshop" points to the comment box; "Gray slides provide sample student responses" points to a gray slide at the bottom left; and "Color-coding by KI process:" points to the legend.

Location	Rate
Richmond	88.3
Contra Costa	62.8
Hospitalizations	38.8
Richmond	13.6

**CUSTOMIZATION IDEAS:**

- Can we get another data set from another city not having refinery?
- Can be used as formative assessment

**Color-coding by KI process:**

- Elicit Ideas
- Discover Ideas
- Distinguish Ideas
- Reflect + Connect Ideas

The team used the Visualizer to plan adaptations to strengthen the focus on using multiple data sources for investigating social justice issues. For example, they suggested examining data from additional pollution sources such as local highways that are compounding the effect of the refinery. They also suggested ways to guide students in expressing relationships they identify among pollution from the freeways and refineries, redlining policies, and incidences of asthma. They suggested using a protocol to scaffold respectful peer-to-peer conversations and incorporating a journal for individuals to write a more personal and private response.

## Enactment

The workshop gave teachers who were initially eager but uncertain about how to teach social justice in science the confidence to customize and teach an ARISE

unit. Several teachers customized the unit by incorporating activities students had done in other contexts to empower them to make a change. A team of teachers who taught the Chemical Reactions & Asthma unit, for example, had students design infographics that explain the science behind the problem. A teacher who taught the Urban Heat Islands unit gave students the option to make a social media post.

We describe how Teacher B used her experience in the workshop to enact the Chemical Reactions & Asthma unit as a part of their remote instruction in Spring 2021. During enactment, Teacher B led class discussions by guiding students to notice patterns in the data local to their city, as teachers had planned during the workshop. For example, Teacher B guided students to compare asthma rates between their city and a neighboring city as they analyzed the maps shown in Figure 1. After students identified a pattern, Teacher B prompted students to offer an



explanation for why they thought the identified patterns occurred.

Teacher B also facilitated potentially emotional discussions as the teachers themselves had experienced during the workshop. They assured students that each of their perspectives was welcome, such as by remarking, “Can someone tell me . . . what are some factors that you think are why African Americans are affected more? There’s no wrong answer; be a risk taker.” Teacher B also often articulated personal emotions in response to the issue. For example, Teacher B personalized the need for action by saying, “So when I first heard about redlining, I had a pretty strong reaction. I say when I first heard about redlining as an adult because I didn’t have the privilege to hear about it as a middle schooler . . . I say privilege because . . . as seventh graders you can do something about it [and so can I].” Teacher B also empowered her students to take action. She had students write a letter to a local politician about what causes air pollution and recommend changes the politician could make to improve air quality in their city.

Analyzing Teacher B’s students’ explanations at the end of the unit revealed how the unit influenced the students’ views on air pollution and asthma rates as well as how to take action. As shown in Table 3, students learned that because of historical housing policies, some races are more impacted than others by the air pollution from refineries and freeways. Students generated strategies to take action, such as moving refineries away from homes or empowering people who are in the community and experiencing the pollution to serve as policy decision makers, or encouraging the use of alternative fuels, such as using electric-powered cars to reduce air pollution.

## Conclusions

We supported teachers to test and refine three strategies to help them develop collective efficacy for

incorporating social justice into the science curriculum. The strategies of positioning, envisioning, and customizing built efficacy for supporting student emotions around social justice issues and localizing the curriculum. The ARISE open source units and online guide for the workshop model are freely available for teachers and communities wishing to build efficacy for teaching social justice in science. ●

*Note:* OER technologies are either in the public domain or licensed such that everyone has free and perpetual permission to engage in retaining, remixing, revising, reusing, and redistributing the resources.

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## ONLINE RESOURCE

WISE units—<https://wise.berkeley.edu>

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**Libby Gerard** ([libbygerard@berkeley.edu](mailto:libbygerard@berkeley.edu)) is a research scientist and lecturer, **Allison Bradford** is a doctoral student, and **Marcia C. Linn** is Evelyn Lois Corey Professor of Instructional Science, all in the Graduate School of Education at the University of California, Berkeley. **Angela DeBarger** is an education program officer at the William and Flora Hewlett Foundation in Menlo Park, California. **Korah Wiley** is a learning sciences researcher at Digital Promise in San Mateo, California.