CASE STUDY

Project-Based Learning in San Francisco: Research Study Sparks Middle School Science Curriculum

When the San Francisco Unified School District (SFUSD) was looking for a new middle school science curriculum in 2016, it sought a program that would align with the new Next Generation Science Standards and the district's equity goals.

"We had to think about a curriculum and the structures we were going to put in place to meet these standards in science. They did require a significant change in teacher and student practice," stated James Ryan, former executive director of science, technology, engineering, and math (STEM) for the district.

At the same time, SFUSD was committed to vital priorities that included addressing systemic racism and inequity, advancing deeper learning, encouraging student collaboration, and boosting student and family engagement, noted Devin Krugman, the district's director of growth and professional development. "There was magic in how project-based learning supported different priorities," Krugman said, describing how system leaders decided to move to a project-based science curriculum.

A study that included about a dozen San Francisco Bay Area districts investigating project-based learning (PBL) approaches to sixth-grade science influenced the shift. The study involved science teachers, Stanford University researchers, and Lucas Education Research (LER), a division of the George Lucas Educational Foundation. Study findings showed that the sixth-grade students in the PBL classrooms outperformed students learning in traditional classrooms on science, math, and English language arts assessments. In addition, students learning English as a second language did better than peers on a language proficiency test when they had access to the PBL program.

After careful consideration, and support from LER and Stanford, the district decided to leverage the research-backed sixth-grade curriculum at the center of that study to create Equity in Science Education, a PBL science program for middle school students that includes curriculum, teacher professional learning, and research. The effort benefited from strong district leadership, active involvement by science teachers, an evidence base, strategic timing, and an alignment with other priorities. Today, the program is in place across grades 6–8 throughout SFUSD middle schools.

Curriculum design

The Equity in Science Education curriculum is now open and freely available for others to use. It engages students in active, inquiry-based science

instruction and leverages collaborative learning and performance-based assessments.

In each middle school grade, students begin with a focus on collaboration and working productively as a team. The year is then divided into four content-rich, project-based units. Essential questions drive learning and help students generate their own understanding. Throughout the year, students ask questions and define problems about the natural and designed world, design investigations in which they collect information and analyze trends and patterns in their data, develop models of physical phenomena, and communicate findings from their investigations.

The project-based approach allows students to apply what they learn to successfully tackle issues of importance to them, their communities, and the broader world. Students actively engage in their learning, collaborate with peers, and use the authentic practices of scientific fields. Through accessible, standards-aligned assessments embedded over the course of each unit, students have numerous and varied opportunities to demonstrate what they know and can do. The program is also anchored by the research-backed 5E learning progression, an instructional model that supports student-centered learning.

INQUIRY ACROSS GRADES

Content across the grades is generally organized around the following content areas:

- In sixth grade, students consider how to use science and engineering practices to explore energy, climate, body systems, and the growth and reproduction of organisms. In one unit, for example, students explore the question, "How can we design a device to warm something up?"
- Seventh graders investigate chemical reactions, geoscience processes, ecosystems, and the earth's natural resources. Among other questions, they consider, "What materials should be used to make utensils for SFUSD cafeterias?"
- In eighth grade, students explore motion, waves, evolution, and natural selection. An example of a driving question in this grade is, "How can we reduce the spread of antibiotic resistance?"

Teacher support and collaboration

Having a unified curriculum across San Francisco middle schools is a big change from past practices and allows for more-cohesive teaching and learning experiences. "Science was being taught in many different ways—so much so that teachers couldn't collaborate across the hallway from one another, let alone across schools," reported Ryan, the former district STEM director.

Eric Lewis, a middle school science content specialist for SFUSD, explained that district and university curriculum designers developed the approach along with aligned supports for teachers, recognizing that PBL is a highly complex form of instruction. "There is a lot of strong professional development built around the curriculum," he said. In the early days of implementation, the district brought together grade-level teams in the summer and during the year for collaboration, professional learning, and goal setting. They shared student work, videos from different classrooms, and routines and resources. The leadership team also spent time sharing the curriculum with principals and giving them opportunities to engage with it as students would so they would understand deeply how to support science teaching and learning in their schools.

Today, new teachers receive four days of training in the summer, and all teachers continue their

professional learning during the year. And teachers continue to regularly share their teaching practices by inviting others into their classrooms to observe, showing videos of students engaging with the curriculum, and looking at student work together. Teachers have access to and have practiced with protocols and routines that support unpacking all this classroom data. "We're lucky we have teachers who are willing to open up their classroom. Teachers connect with and collaborate with each other a lot," Lewis remarked.

Vicente Patiño, who teaches seventh and eighth grade, agreed. "It's the best kind of professional development. Teachers often model instruction. They might act the part of the students or teachers. I find the professional development really helpful," he said.

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Teacher-leaders from across the district are integral to this approach and are supported with protocols related to reviewing student work, class-based videos, and observation tools.

"The aligned PD is critical. It includes essential supports, like figuring out how to enact what that student-centered classroom looks like," explained Janet Carlson, an associate professor at Stanford University's Graduate School of Education and the lead researcher on the project. Carlson added that training sessions include critical and challenging topics like how to foster class discussions on sense making and how to ensure equity is at the center of instruction. She described how teachers routinely work together to analyze student work, look for evidence of learning, and identify ways to sustain a positive classroom culture.

That's vastly different from the kind of professional-learning experiences most science teachers received in the past, according to Sarah Delaney, the former supervisor of science for SFUSD and a former teacher in the district. She said that when she started out as a science teacher, professional learning and related teacher exchanges centered on what kinds of labs or exciting activities teachers were doing with students rather than exploring whether and to what degree the kids were learning and collaborating. "Those are much deeper conversations," Delaney said. "The change reflects the power of a common, high-quality curriculum to empower teachers to have deeper conversations about teaching and learning."

Adaptability for authenticity, agency

Authentic learning experiences anchor rigorous project-based learning programs, as do opportunities for students to lead their learning and develop agency. Both design principles are evident in Equity in Science Education, which is adaptable for local classroom contexts. There is an arc to the lessons, but teachers are encouraged to connect them to the interests and needs of their students.

Maggie Dominguez, an eighth-grade math and science teacher, said this is important. During pandemic-related distance learning in the 2020–21 school year, she felt particularly compelled to be creative with projects to ensure they were authentic to students' lives and were engaging. She adapted a physics lesson in a unit on motion to work on an issue her students cared a lot about—the safety of walking and cycling in their city neighborhoods. Students learned core academic content, including Newton's laws of motion, by studying collisions. And they came up with ideas for protecting cyclists and pedestrians, such as creating slow-street initiatives and instituting speed bumps.

Former STEM director Ryan said in developing Equity in Science Education, the program's designers sought to break away from the view that teachers must deliver the curriculum with strict fidelity, a term he said has become a synonym for compliance. "Teaching is not an act of compliance. We wanted to create a structure, a culture, in which teachers owned their curriculum," he stated, adding that such adaptations are most effective when teachers share and learn from each other.

Lewis, the science content specialist, loves visiting science classrooms and seeing how

different communities take the curriculum and connect it to their own lived experiences. He described the joy of visiting a seventh-grade class studying climate science and hearing students passionately discussing their own school's carbon footprint. They followed the curriculum's prompt to consider what materials should be used to make utensils for the district's cafeterias. In discovering their school was using plastic, the students researched alternatives and wrote to the district's environmental equity team to push for a more environmentally friendly alternative. Another group looked at food waste in their cafeteria and came up with more-sustainable alternatives. In each case, the students were personally interested in the issues involved and developed and demonstrated agency, all the while learning core material, Lewis remarked.

A focus on equity

The PBL science curriculum is rooted in equity-centered design principles and uses related instructional approaches. That's important, because students from low-income backgrounds, students of color, and English language learners are less likely to experience approaches—like PBL—that are deeply engaging, ask enough of them, and develop student ownership over learning, according to the TNTP report "The Opportunity Myth." By offering PBL across middle grades, SFUSD is working to directly address that problem and support deep engagement for each and every student.

Former STEM director Ryan added that students who attend schools in high-poverty, minority areas are particularly less likely to have robust science instruction than their wealthier, White peers because there is a strong focus in underserved schools on improving math and reading scores—the two core subjects on which state and federal accountability frameworks are built.

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Traci Wrycza, who teaches seventh and eighth graders, sees the curriculum as a strong form of equity-centered instruction. "Project-based learning is more engaging and equitable than traditional approaches. With teacher support, every kid has a voice. Often some students, such as minority students, are overlooked. This is a step in the right direction in overcoming that," she said. "It's not busy work. Students are challenged to engage. You can't hide. You can't be overlooked. You have to participate. You're part of a team."

The curriculum uses a framework developed by the Program for Complex Instruction at Stanford University that improves collaborative learning experiences. It calls for the use of specific strategies to enhance the level of student discourse and engagement and encourage equitable participation.

The curriculum also places a special emphasis on literacy supports, which is helpful for both English learners and students who struggle with reading. And it encourages equitable, collaborative interactions between students. That's vital. Researchers with the nonprofit American Institutes for Research previously released a study suggesting collaborative learning experiences as among the factors that can contribute to positive changes in the academic trajectories of Black students. San Francisco

teachers applaud this aspect of the curriculum.

"They're definitely learning how to work with others more," Patiño reported. "I particularly like the units that explicitly focus on group work. It prepares students for the type of work we're going to have them do. It prepares students for their roles, sets norms, and gives students ideas for what to expect and what's expected of them."

Lewis, the science content specialist, added that "notebooking" is a feature of the curriculum that creates equitable learning opportunities for students with learning differences. Students keep notebooks, which allows them to demonstrate their thinking and progress in ways that work best for them individually. The curriculum designers also embedded individual projects alongside group projects, which helps different kinds of learners succeed.

Delaney, the former district science supervisor, noted that the curriculum requires the use of supplies for hands-on lessons, and SFUSD provides those to classrooms districtwide. She said, in contrast, many science teachers around the country pay for their own lab supplies, fundraise for them, or spend time looking for grants. "There are huge equity issues involved," she said, adding that districts should prioritize sustained funding for classroom materials when implementing a new PBL science curriculum.

Lessons learned, advice for others

Equity in Science Education is free and available for anyone to use, and leaders in San Francisco are getting numerous inquiries about it from around the country. For district leaders who want to create their own resources for their local contexts, SFUSD professional-development director Krugman's suggestion is to allocate sufficient time and resources to the effort and engage external partners and experts who can help.

Krugman also noted that moving to project-based learning is a big shift. To succeed, it should fit within the district's broader priorities, she said. For example, when SFUSD was selecting a middle school science curriculum, it was also going through an overall middle-grades redesign effort, moving to block scheduling and emphasizing deeper learning and other student-centered approaches that aligned well with project-based learning. Other aligned priorities include an emphasis on fostering the competencies highlighted in the SFUSD graduate profile, a set of skills and knowledge all students should have upon leaving high school so they can compete and thrive.

At the very onset of curriculum development, the district established a team of teachers to consider the best path forward, and district leaders empowered former STEM director Ryan to help lead the effort. He kept leaders and teachers

SFUSD ADVICE FOR DISTRICT LEADERS

- Assess how implementing a program like Equity in Science Education aligns with other district priorities
- Leverage opportunities like adoption cycles and new standards to make change
- Adopt a common approach so teachers across the district can collaborate around it
- Allocate adequate, sustained resources and dedicated district staff
- Engage outside experts
- Ensure structures and schedules support the shift in instruction
- Lift up professional learning by providing the time and ongoing opportunities
- Engage and support teacher-leaders
- Cultivate a collaborative mindset
- Showcase early indicators of success and apply a continuous improvement process

Images courtesy of Edutopia

up-to-date on curriculum development and implementation and shared points of success along the way, which he said helped with buy in. "We had to do a good job at showing the impact of the work we were doing," he remarked. In the early days of implementing the program, his team couldn't wait for end-of-year state test scores as data points but had to show other indicators to encourage school board officials, administrators, and principals to support the new approach. Those included data points like attendance figures and teacher and student surveys.

Carlson, the Stanford education professor, noted that having a point person like Ryan in leadership who developed and partnered with teacher-leaders was a good formula for success. Teachers involved were placed on special assignment outside the classroom so they could devote enough time and energy to the effort. "It had strong leadership at the top without being top-down," Carlson said.

Lewis, the science content specialist, added that teacher-leaders provided the district with vital feedback on the curriculum and the needs related to books, materials, and supports. The Stanford team supported the teacher-leaders in their work. "I would definitely recommend that folks that are implementing a teacher-leadership program look for support from other groups that have been doing this kind of work for a long time," Lewis said.

San Francisco leaders also chose an optimal time to pursue the project. California had adopted the new science standards, and the district was committed to choosing an aligned curriculum. There were limited resources on the market at the time, so it was a good moment to try developing something new.

However, Ryan stressed that it's important to remember that whole-system change is about adopting new curricular resources but also is much more than that. "Curriculum is an absolutely necessary component to leading the change and also inadequate for the job," he said, adding that strong professional learning, shifting culture and mindsets, and aligning curriculum adoptions with other district priorities are also vital.

His advice for district leaders interested in this work is to allocate enough time for deep science learning, cultivate a collaborative mindset among teachers so change happens beyond individual classrooms, establish structures for teachers to collaborate, and make rigorous science instruction available for all students.

To find the Equity in Science Education curriculum, visit Sprocket, an online platform hosted by LER. Or if you're working on developing a PBL curriculum, we'd love to hear how it's going and learn from you. Reach out by email at webadmin@lucasedresearch.org, or we are @lucasedresearch on Twitter.

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