The Education Trust–West

THE **STEM** TEACHER DROUGHT

CRACKS AND DISPARITIES IN CALIFORNIA'S MATH AND SCIENCE TEACHER PIPELINE

SEPTEMBER 2015

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In today's fast-moving and interconnected world, high school and college graduates must be able to think critically and generate creative solutions to address complex problems. With the world producing new knowledge at an exponential rate, we can't anticipate what all these future challenges will be. But without a doubt, they will impact a society that is more diverse and complex than ever before. This is especially true in California, where the majority of the population is non-White and increasingly low income, and almost half of its residents speak a language other than English at home. Our young people — particularly those who are Black, Latino, multilingual, or who grow up in under-resourced communities — must play a central role in addressing California's social, economic, and environmental challenges. Indeed, only by cultivating citizens, workers, and innovators who reflect the state's diversity will we be able to generate the best solutions for California's future.

It is particularly urgent that California's diverse students develop skills in science, technology, engineering, and math — or STEM. Seven of the state's 10 fastest growing occupations are in STEM fields,[1] and many other occupations require literacy in math and science. Further, the problem-solving, analytic, and critical thinking skills demanded by STEM fields are also applicable to a host of other sectors and real-world problems – including the climate change and water shortage challenges our state faces. For all these reasons, STEM skills are also the ones parents across California want their children to learn. And they are the skills our new state standards — including the Common Core and Next Generation Science Standards — are intended to cultivate in our students.

It's urgent that California's diverse students develop skills in science, technology, engineering, and math — or STEM.

Yet while STEM learning opportunities are abundant in some schools and districts, they are not available to far too many of our students. Indeed, African American, Latino, and low-income students in California have less access to STEM learning opportunities and experience worse academic outcomes in STEM subjects as compared to their more advantaged peers. The list of obstacles is frustratingly long: these students attend high schools with fewer rigorous math and science courses, have less access to high-quality science labs, and have fewer STEM enrichment opportunities outside of school, to name just a few.

Despite this long list of barriers, our report focuses on the one element we believe is most foundational for ensuring quality STEM learning: teachers. Three critical questions guide our analysis:

1. Are districts, especially those serving concentrations of low-income students, able to meet their demand for math and science teachers?
2. Are high school math and science teachers appropriately credentialed in STEM subject areas, particularly in our highest poverty districts?
3. Are teachers, particularly those in our highest need schools, prepared and supported to effectively teach our new, more rigorous math and science standards?

By Leni Wolf, *Research and Policy Analyst at The Education Trust–West.*

For each question, we present evidence on disparities affecting California students. Through an original analysis, we find troubling gaps between the supply of and demand for STEM teachers. In essence, there is a STEM teacher drought, particularly in certain kinds of districts. By our estimate, the state is falling short by about 200 STEM teachers per year. This shortfall affects roughly 28,000 students per year, with these students likely shuffled into other courses or taught in larger classes. We find clear patterns of difference across school communities: higher poverty, rural, and city districts, as well as elementary districts and county offices of education, are less able to meet their demand for STEM teachers than lower poverty districts and those located in town and suburbs. For example, higher poverty districts are able to fill roughly 87 percent of their STEM teacher vacancies, compared with 95 percent for middle poverty districts. This scarcity stacks up to lost opportunities for California's highest need students.

We also find differences in the percentage of teachers who are qualified to teach math and science based on their credentials. In fact, students in the highest poverty districts are about three times as likely as their peers in the lowest poverty districts to be taught by teachers lacking a full credential and/or STEM subject-area authorization.

But credentials aren't all teachers need to be prepared. We find that math and science teachers, particularly those in high-poverty districts, lack the induction, support, and development they need to be effective at their craft – especially as the state transitions to new standards.

After presenting these data, we feature districts and universities taking promising steps to address these challenges. We conclude with recommendations for school district and state leaders to consider as they work to make it possible for all students to access high-quality STEM learning opportunities.

INSUFFICIENT STEM OPPORTUNITIES LEAD TO LOW OUTCOMES

California's students — especially those who are Black, Latino, and low income — have insufficient access to STEM learning opportunities. It's therefore no wonder that academic outcomes are as low as they are.

ELEMENTARY SCHOOL

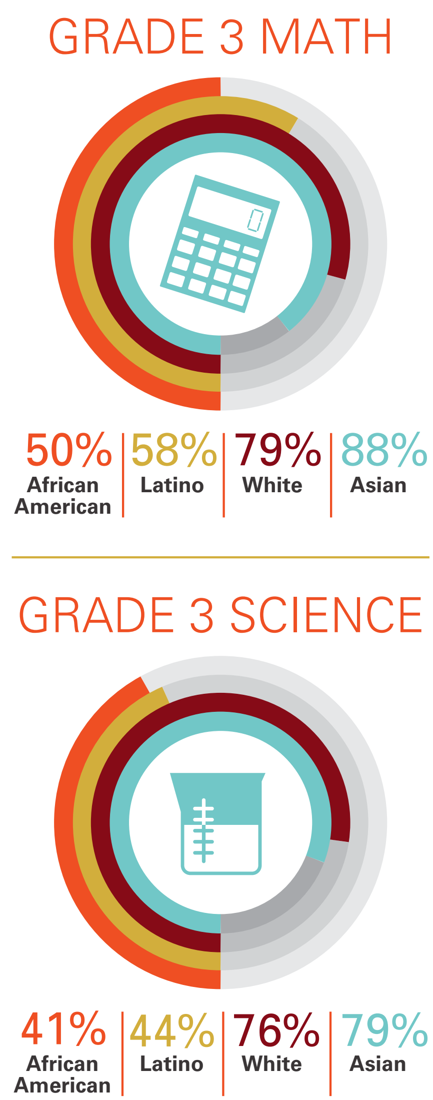
From the earliest grades, California's students have little exposure to science education:

- Four in 10 elementary teachers in California say they spend less than one hour per week on science.[2] On average, California's fourth graders get just 27 minutes per day of science instruction.[3]
- Only 10 percent of elementary students regularly engage in "practices of science" that include hands-on instruction and labs, data analysis, and writing.[4]
- More than one-third of elementary teachers in high-poverty schools report that facilities are a challenge to science instruction, compared with 13 percent of teachers in low-poverty schools. And principals in more affluent schools are twice as likely to say they have launched science initiatives in their schools.[5]

Achievement gaps emerge early between Black, Latino, and low-income students and their peers, as evidenced by 2013 California Standards Test (CST)[6] results:

- Just 50 percent of African American students and 58 percent of Latino students are proficient in third grade math, compared with 79 percent of White and 88 percent of Asian students.
- In fifth grade science, 41 percent of African American students and 44 percent of Latino students and proficient, as compared with 76 percent of White and 79 percent of Asian peers.

FIGURE 1: Percent of students scoring proficient or advanced on the California Standards Tests (CSTs) in 3rd grade math and science, 2013



Source: California Department of Education, 2013.

MIDDLE SCHOOL

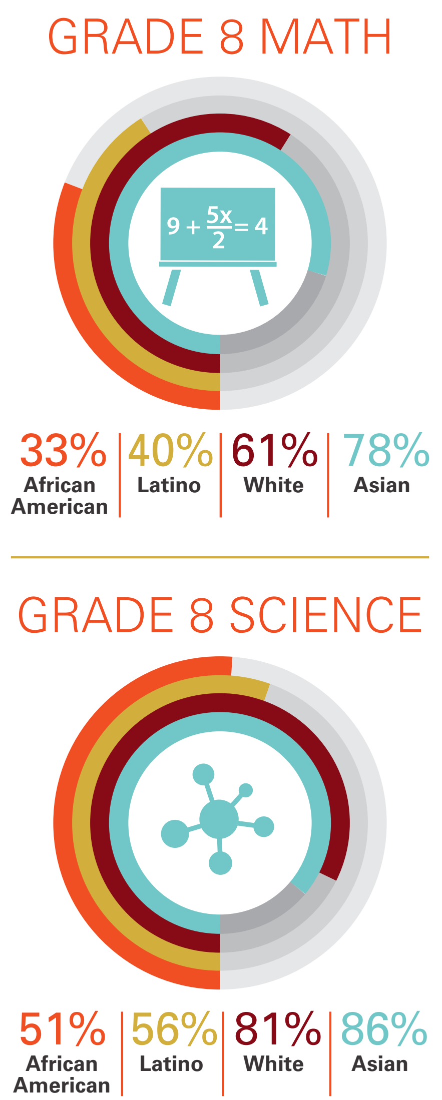
Access to science opportunities at the middle school level continues to be an obstacle to STEM learning:

- Only 14 percent of middle schoolers regularly engage in "practices of science" that include hands-on instruction and labs, data analysis, and writing.[7]
- Over 70 percent of teachers report that limited funds for equipment and supplies are a major or moderate challenge to science instruction.[8]

Achievement gaps continue into middle school as well, according to 2013 CST results:

- Only a third of Black students and 40 percent of Latino students who took Algebra I in eighth grade were proficient compared with 61 percent of White and 78 percent of Asian students.
- Though eighth grade science proficiency rates were slightly higher, similar gaps were evident, with White and Asian student proficiency rates 30 percentage points higher than those of Black and Latino students.

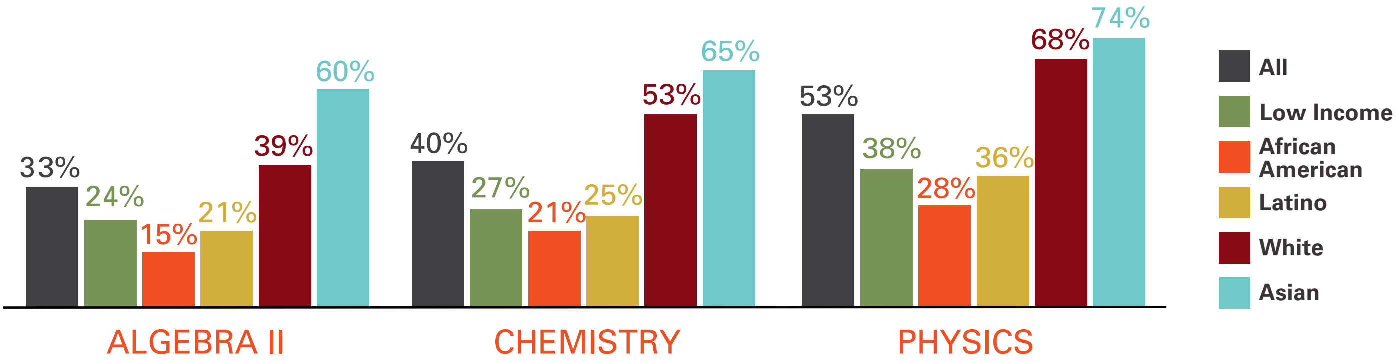
FIGURE 2: Percent of students scoring proficient or advanced on the California Standards Tests (CSTs) in eighth grade math and science, 2013



Source: California Department of Education, 2013.

HIGH SCHOOL

FIGURE 3: Percent of students scoring proficient or advanced on the California Standards Tests (CSTs) end-of-course exam in high school math and science, 2013



Source: California Department of Education, 2013.

(For additional data on STEM opportunities and outcomes, see "California STEM Education: by the Numbers," a complementary document to this report.)

In high school, access to rigorous STEM coursework varies dramatically across student subgroups:

- Black and Latino students are often tracked away from rigorous academic coursework and provided inadequate academic supports, or do not even have the opportunity to enroll in advanced STEM courses due to limited course offerings.[9] In a sample district we reviewed, the percentage of students enrolling in the 15 A-G courses required for admission into the University of California and California State University college systems (which include three math and two lab science courses) is just 50 percent for Black and Latino students compared to 65 percent of White and 85 percent of Asian students.[10]
- Just 27 percent of schools serving the highest concentration of students of color offer computer science classes compared to 45 percent of schools with the lowest concentrations of these students.[11]

Achievement gaps persist through high school, as 2013 CST results make clear:

- In Algebra II, just 15 to 24 percent of low-income, Black, and Latino students are proficient or above, while almost 40 percent of White and 60 percent of Asian students are proficient.
- Just 21 percent of Black students are proficient in chemistry, while 53 percent of White students are proficient. In physics, Asian proficiency rates are more than double that of Latino students (74 versus 36 percent).

THE DATA ARE CLEAR: Math and science outcomes are far worse than they ought to be for California's African American, Latino, and low-income children. More effective teaching is undoubtedly part of the solution, but it's short-sighted to focus only on instruction if we don't have enough qualified math and science teachers to begin with. We now turn to data on the availability of STEM teachers.

DO CALIFORNIA'S SCHOOLS HAVE ENOUGH MATH AND SCIENCE TEACHERS?

We find that the demand for STEM teachers outweighs the supply.

To come to this conclusion, we compared the number of new math and science teachers districts projected they would need to hire for 2013-14 to the number of new STEM teachers districts actually hired that year. We considered STEM teachers to be those whose full-time teaching load included math, science, or a combination of those subjects. Overall, we found that districts were able to fill less than 93 percent of open STEM positions in 2013-14. This left a total shortage of approximately 200 STEM teachers.

If we suppose each of these missing teachers could have taught five course sections[12] with an average of 28 students in each section,[13] the shortage of STEM teachers in 2013-14 alone likely affected about 28,000 California students. (For additional information about how we arrived at our calculations, see the Technical Appendix.) Many of these students probably received less STEM learning time, either because they had to take substitute non-STEM courses or were placed into larger math and science classes, where they received less individualized attention and had fewer hands-on learning opportunities.

FIGURE 4: Supply of and demand for new STEM teachers in California, 2013-14

Source: The Education Trust–West analysis of California Department of Education's 2012-13 Basic Educational Data System (CBEDS) and 2013-14 staff assignment and demographic data files.

WHICH DISTRICTS AND COMMUNITIES EXPERIENCE THE GREATEST SHORTAGES?

The extent of the 2013-14 STEM teacher shortage varied across districts. (See Figure 5 for full details of the trends highlighted here.)

District Type: High school districts were more likely than other district types to fill open positions. County offices of education were the least likely to fill open positions, hiring only 80 percent of the STEM teachers they projected they would need. Elementary districts experienced the next greatest challenge, followed by unified districts. (We should note that charter schools were included in districts and county offices of education if they are authorized by them.)

Student Poverty: The highest poverty districts had a harder time filling open STEM positions than other districts, filling just 87 percent of those vacancies. (For our analysis, "highest poverty" districts are those whose percentage of students qualifying for free or reduced-price meals puts them in the top quartile statewide. "Lowest poverty" districts are in the bottom quartile, and "middle poverty" districts represent the middle 50 percent.)

District Location: Districts located in towns (defined here as territories located inside urban clusters) were much more likely to fill open STEM positions than districts in any other locale.[14] They hired significantly more STEM teachers than they initially projected they would need. Suburban districts easily filled their open math positions. Districts in cities were least likely to meet demand, filling about 3 out of 4 of these positions. Similar trends were evident for rural districts.

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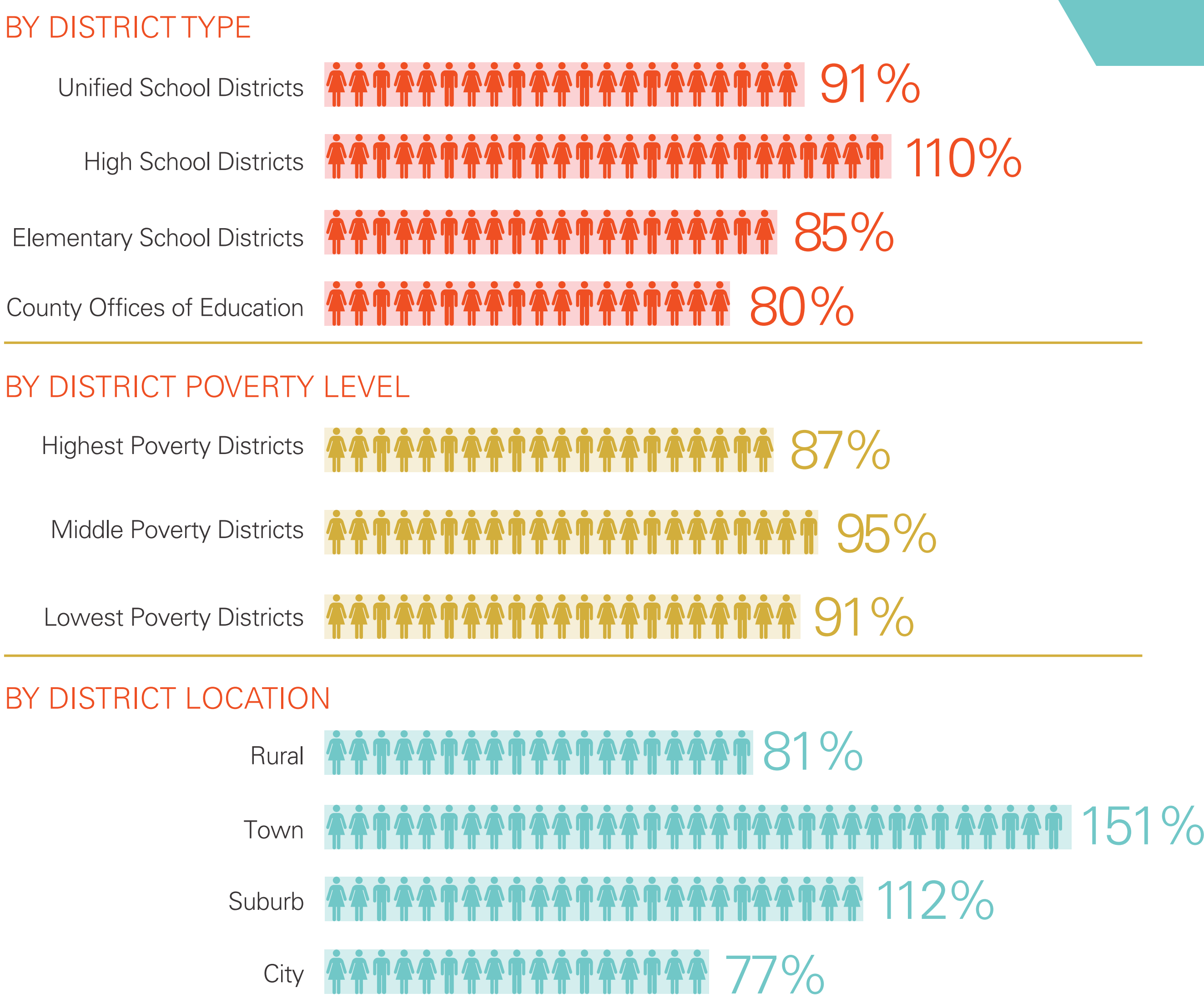
FIGURE 5: STEM teacher demand met in California by district characteristics, 2013-14

PERCENT OF STEM TEACHER DEMAND MET

(Number of New Hires / Number of Vacancies)



Source: The Education Trust–West analysis of California Department of Education's 2012-13 California Basic Educational Data System (CBEDS) and 2013-14 staff assignment, staff demographic, and free or reduced-price meal files; 2015 public schools database; and 2005-06 National Center for Education Statistics' Local Education Agency (School District) Locale Code file. "Demand met" of greater than 100% signifies that these district types hired more STEM teachers than they originally projected they would need.

WHY IS THERE A STEM TEACHER SHORTAGE?

Our supply-versus-demand analysis makes it clear that we have a STEM teacher shortage. This shortage, which is especially evident in science, affects districts of varying types and poverty levels, and across different locales. Why does this STEM shortage exist? Trends in teacher preparation and hiring provide insight into some of the reasons:

General teacher shortage. The decline in new STEM teachers mirrors the looming teacher shortage in California. Enrollment in teacher preparation programs has dropped dramatically. In 2012-13, about 20,000 candidates were enrolled in 89 teacher preparation programs in California — 53 percent fewer than five years earlier. And in STEM, the number of newly prepared math and science teachers has declined during the past five years, from more than 3,000 in 2009-10 to 2,100 in 2014-15.[15] Fewer new teacher candidates, combined with a large wave of retirements approaching,[16] means that meeting teacher demand will become increasingly challenging.

Not all STEM program completers are entering the teaching profession. Of the 2,100 newly credentialed STEM teachers in 2014-15, almost 1,400 completed a math credentialing program and more than 1,000 completed a science credentialing program. This could have been enough to fill California's STEM teacher vacancies. Yet we still have a shortage. There are likely a number of reasons for this phenomenon, including the opportunities STEM job seekers have outside of teaching and the over-concentration of teachers candidates in some regions.

STEM professionals have other career opportunities. Almost 20 percent of teachers leave the profession within the first five years.[17] Some sources suggest that figure is doubled for high school STEM teachers.[18] Although reasons for leaving are varied and often complex, some teachers cite financial grounds as a factor.[19] STEM teachers may have more compelling reasons to leave, given their earning potential in careers outside of teaching. In California, the average starting teacher salary in 2012-13 was around $41,000,[20] whereas the average entry-level STEM job paid about $68,000.[21] California is home to six of the nation's 15 highest paying STEM job cities,[22] including the technology-rich Silicon Valley, where starting teacher salaries are still often less than $50,000. Given the lure of readily available jobs and lucrative salaries, it's not surprising that few math and science majors are likely to consider teaching in the first place. We spoke with an engineering major who left a well-paying engineering position to teach high school physics and chemistry. Although he felt teaching was his calling, he decided after just three years that his teacher salary was financially unsustainable. He recently decided to return to an engineering firm rather than the classroom.

California's students, and particularly its most vulnerable learners, bear the brunt of the state's unfulfilled teacher demand. The shortage leads to overcrowded classrooms and fewer opportunities to take STEM coursework. This scarcity means lost opportunities for California's students.

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DO STEM TEACHERS HAVE THE BASIC QUALIFICATIONS NEEDED TO TEACH SCIENCE AND MATH?

California's STEM teacher shortage becomes even more concerning when we discover that not all math and science teachers have the basic qualifications, based on their credential status and authorization type, to teach their assigned content area. This is before we even consider their familiarity with STEM content and standards, which we will explore in the next section. Although a credential does not guarantee a teacher's ability to meaningfully engage students and help them learn, it's an important starting point.

Fully credentialed teachers are those who have completed a credentialing program and hold a preliminary, clear, or life credential. In addition to a credential, teachers also have subject-area authorizations. For elementary teachers, a self-contained or multiple-subject authorization allows them to teach science and math along with all other subject areas. At the high school level, teachers with appropriate STEM authorizations are those who have fulfilled the requirements of one or more math or science-related, single-subject or secondary-subject area authorizations, such as physics or mathematics. For this next analysis, we look at only high school math and science teachers because most designated STEM teachers teach at the secondary level.

Although the bulk of STEM teachers are fully credentialed, we find differences in the percentage of teachers who lack basic qualifications to teach math and science by district poverty level. Students in the highest poverty districts are 2.7 times as likely to have a math teacher who is not fully credentialed and/or lacks a math subject-area authorization compared with their peers in more affluent school districts. And in science classrooms, students in the highest poverty districts are three times as likely to have a teacher lacking a full credential and/or science authorization, compared with their peers in more affluent districts. (See Figure 6.)

These figures are significant when we consider their impact on students. For example, the 300 high school math teachers in high-poverty districts who were not fully credentialed in math likely taught more than 40,000 California students. That means tens of thousands of students, most of whom were low income, learned high school-level math from a teacher lacking basic qualifications.

FIGURE 6: Unqualified math and science high school teachers in highest and lowest poverty districts

Source: The Education Trust–West analysis of California Department of Education's 2012-13 California Basic Educational Data System (CBEDS) and 2013-14 staff assignment, staff demographic, and free or reduced-price meal files; 2013-14 Staff Credential Record file; 2015 Public Schools Database; and 2005-06 National Center for Education Statistics' Local Education Agency (School District) Locale Code File.

Evidence from California's State Plan to Ensure Equitable Access to Excellent Educators shows that students of color are also disproportionately taught by unqualified teachers. In fact, students of color are more than twice as likely to be taught by unqualified teachers who are hired by a district on a provisional or short-term basis due to teacher vacancies.[23] And students of color are more likely to be taught by out-of-field teachers who are assigned to classes or subjects outside of their credentialed area.

Some regions of the state employ more underqualified STEM teachers than others. For example, rural counties issue a higher percentage of provisional permits than other counties.[24] This could occur because fewer preparation programs exist in rural areas, and rural communities tend to have greater difficulty attracting candidates. Some teacher preparation programs, however, are working to increase the number of qualified teachers in these areas. For example, California State University–Monterey Bay and Cal Poly San Luis Obispo are working to strengthen their credentialing programs while simultaneously building a pipeline of teachers into 10 local school districts. (Read more about the **Central Coast Partnership for Teaching Excellence** on page 16.)

A credential alone doesn't guarantee that teachers will be effective at their craft. Conversely, not all uncredentialed teachers are ineffective. But when students are taught by teachers lacking appropriate credentials and critical subject-matter knowledge, students are far less likely to experience high-quality STEM instruction.

ARE STEM TEACHERS PREPARED TO TEACH CHALLENGING CONTENT?

Teacher supply needs to meet demand, and teachers should have basic credentials. But teachers must also possess the skills, content knowledge, and experiences necessary to prepare them for the demands of the classroom, particularly as our new math and science standards alter the very nature of the teacher-student interaction and call for a great emphasis on interdisciplinary learning. And as they progress through their careers, teachers should receive ongoing, high-quality support to improve their craft.

Sadly, many teachers — even those who enter the classroom fully credentialed — feel underprepared to teach math and science. In 2011, a year after the Common Core State Standards were adopted but before most districts began implementing them, a survey found that only 30 to 45 percent of primary and secondary teachers teaching CCSS math topics felt well-prepared to do so.[25] Even fewer teachers felt prepared to teach science, especially at the elementary level: only about one-third of elementary teachers surveyed felt "very prepared" to teach science, and only a quarter expressed confidence in teaching particular topics such as physics.[26] When researchers surveyed a sample of California elementary school principals, fewer than half said it was likely their students received high-quality science instruction, and 12 percent reported it was "not at all" likely their students were receiving high-quality instruction.[27] These findings describe feelings of teacher preparedness prior to adoption of the new standards. The introduction of these more rigorous standards only exacerbates concerns around inadequate preparation, as articulated in the next section.

DO STEM TEACHERS POSSESS BASIC CONTENT KNOWLEDGE?

That too many math and science teachers enter the profession without the content knowledge and preparation they need to help all their students learn. Indeed, it is common for teachers to struggle to teach complex — and sometimes even simple — mathematical and scientific concepts, though the nature of this challenge varies across grade levels.

At the elementary level, where most teachers teach all subjects in self-contained classrooms, content-specific preparation in credentialing programs is often limited. High school teachers, by comparison, typically acquire deeper content knowledge at the undergraduate level in their teaching subject. A high school geometry teacher, for example, may have been a math major in college. But holding a degree in the subject matter taught is not a requirement, as long as he is able to pass a subject-matter test. Because California credentialing programs tend to focus on development of pedagogical skills over content knowledge, and the two are not well-integrated,[28] candidates who did not previously study math or science in depth receive limited additional exposure throughout their preparation program. They often enter the classroom having been trained, at best, on how to teach but not on the actual material they are teaching. As a result, it is not uncommon for teachers to learn the content alongside their students once in the classroom — or perhaps just days or weeks in advance as they read ahead in the textbooks and prepare lessons. As one science teacher in San Francisco said: "I have a solid grasp of physics, but I'm still learning science content from the textbook the day before a lesson."

School systems and credentialing programs must also anticipate future content knowledge needs. For instance, students, parents, business leaders, and higher education leaders are increasingly demanding that students get more exposure to computer science education.[29] However, only small numbers of students currently have access to computer science courses, in part because few teachers possess the necessary content knowledge and qualifications. The California Commission on Teacher Credentialing is working to address this issue. It has proposed strengthening the requirements for obtaining a supplementary authorization in computer science through more rigorous coursework such as computational thinking and computer programming.[30]

DO STEM TEACHERS RECEIVE ENOUGH ONGOING DEVELOPMENT AND SUPPORT?

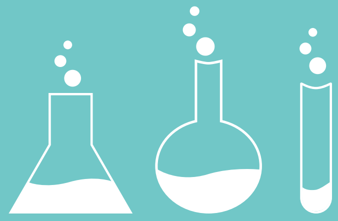
No amount of preliminary preparation can replace the in-school supports teachers need once they are in the classroom. Research overwhelmingly supports the notion that teachers receiving structured feedback and support are more likely to improve their craft and feel supported as professionals, with increased job satisfaction leading to positive outcomes such as teacher retention and improved student outcomes.[31] Unfortunately, few teachers get the regular feedback and supports they need and want. Providing this support is crucial because teachers say that their school environment and the extent to which they feel supported are among the most important factors in continuing to teach.[32]

Sadly, professional development opportunities for teachers have decreased substantially over the past decade. At least half of California's school districts eliminated or severely reduced professional development during the Great Recession, with STEM professional learning opportunities being particularly hard hit.[33] A 2011 study found that 85 percent of elementary school teachers had not received any science development in the previous three years, and middle school teachers said a lack of professional development opportunities posed significant challenges to their ability to implement the science curriculum.[34] Notably, elementary teachers in the highest poverty schools were 20 percent less likely to receive support in assessing personal content knowledge and their own teaching effectiveness than teachers in the lowest poverty schools.[35] In general, districts and schools serving low-income communities are likely to feel the effects of budget cuts more than other schools and districts that can rely on local parcel taxes, local fundraising, and larger reserves during tough economic times.

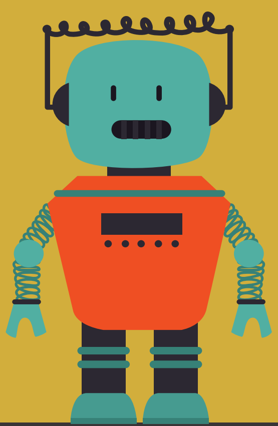
With economic conditions slowly improving, some districts have restored or even increased funding for professional development and new teacher support programs like Beginning Teacher Support and Assistance (BTSA). Others have chosen to invest more heavily in other local priorities. Although the new funding formula offers districts more discretion over programs and spending than in decades past, many scholars and practitioners agree that investing in professional development for teachers is even more critical as the state implements the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS), which were adopted in 2010 and 2013, respectively.[36] In addition to the state's previous investment of $1.25 billion for standards implementation, the 2015 California State Budget provides almost $500 million in one-time funding to support educator effectiveness initiatives during the next three years. This money, which can be spent on professional development programs, coaching, and support services, provides an excellent opportunity for districts to prepare teachers to teach to the new standards. However, it is not a substitute for the ongoing teacher development work districts must invest in to ensure a smooth transition and continued professional growth for educators and school leaders.

Although the introduction of new standards often presents challenges for school systems and teachers, this is especially true of Common Core and the Next Generation Science Standards. These standards demand more from math and science teachers — many of whom were already underprepared prior to the introduction of these new standards. However, even the best and most experienced teachers face a learning curve. Table 1 shows how the Common Core math standards and the NGSS present new challenges for teachers, with similar themes evident across both sets of standards.

TABLE 1: Ways in which Common Core Math Standards and Next Generation Science Standards demand more of teachers than previous standards.



	WHAT'S DIFFERENT ABOUT THE NEW STANDARDS?	HOW TEACHERS ARE IMPACTED
Common Core Math Standards	They focus on mathematical reasoning and understanding over rote memorization.	Teachers must learn new ways of teaching and assessing student learning.
	They emphasize real-life applications instead of math that is disconnected from daily use.	Teachers must expand curriculum to create more real-world learning opportunities.
	They emphasize student communication through constructing oral and written arguments and critiquing reasoning (as supported by the Standards of Mathematical Practice), whereas previous standards required fewer critical thinking skills.	In addition to teaching to gaps in specific math concepts that are new to students, teachers must provide more language support – especially for English learners.
Next Generation Science Standards	They are interdisciplinary, reflected by three, previously more fragmented dimensions: science and engineering practices, cross-cutting concepts,[37] and core facts and ideas.	Fusing the three dimensions requires creating (and adapting to) new curricula and instructional materials.
	They represent a progression of knowledge that builds coherently from K-12 and increases in complexity — in a more cohesive way.	Courses and curriculum sequencing must be restructured, and instruction will need to be more closely aligned across grade levels.
	They promote a deeper understanding of content and its real-life application rather than focusing on amount of content and learning of basic facts.	Increased rigor for students requires instructional techniques that push students further and create more real-world learning opportunities.
	They highlight engineering and technology as key scientific disciplines at all grade levels[38] — rather than spotty attention in just a few upper grades.	All teachers will need to infuse their classes with these elements, and for some, the content will be completely new.



To successfully implement these new standards, districts need to provide educators with ample professional development time and in-class support, and they must carve out time for teachers to plan and work with one another. Fortunately, some districts have begun to do this. For examples of promising district initiatives to support teachers during NGSS and Common Core math implementation, see **District Bright Spots**.

CENTRAL COAST PARTNERSHIP FOR TEACHING EXCELLENCE

In 2014, the U.S. Department of Education awarded $35 million through its Teacher Quality Partnership Grant to 24 institutional partnerships to recruit, train, and support STEM teachers over the next five years, with an emphasis on women and people of color. Seven of the 24 grantees are California institutions.

The University Corporation at Monterey Bay is one of these grantees, securing almost $9 million to implement the Central Coast Partnership for Teaching Excellence. The plan represents a unique partnership between CSU–Monterey Bay, Cal Poly San Luis Obispo, and 10 local school districts. It proposes to have CSU–MB improve the curriculum of its existing teacher preparation program and for Cal Poly to strengthen its teacher residency program, both while developing partnerships with high-poverty rural districts along the Central Coast to strengthen the local STEM teacher pipeline.

These university partners are building on each other's areas of expertise in the field of education. CSU–MB has experience in the clinical teaching model that provides teacher candidates with deep practical classroom experience. This will continue to be a central component of its program while also helping to strengthen and expand this model at Cal Poly. Believing that practical training should be the heart of any teacher preparation program, CSU–MB is also focused on what Mark O'Shea, professor of education and coordinator of the single-subject credentialing program, describes as the "grow your own" model.

"One of the big challenges in getting STEM teachers to poor, remote schools is that if you bring them from the outside, they don't stay long," he said. "We focus on finding young people in those communities and encouraging them to become teachers."

Cal Poly will continue its work through its Center for Excellence in STEM Education (CESAME), which seeks

to improve STEM education, teacher education and professional development, and the workforce pipeline in California. Through partnerships with local K-12 schools, CESAME sends college students to schools to share STEM materials and also brings K-12 students onto the Cal Poly campus to spark their interest in STEM. And because Cal Poly also has well-known STEM faculty, CSU–MB plans to call upon those faculty members as consultants as it continues to build its teacher credentialing programming.

O'Shea is optimistic about future outcomes for teachers and students, even though the benefits may not be immediately apparent. "We're more focused on quality than quantity," he said. "We want to get teachers to high-need schools and keep them there."

DISTRICT BRIGHT SPOTS

SWEETWATER UNION HIGH SCHOOL DISTRICT *serves more than 40,000 students in the southernmost part of the state, almost 60 percent of whom are low income. Three-quarters of the students are Latino, 8 percent are Filipino, and 6 percent are White. The district began the shift to NGSS two years ago, on the heels of reading and writing curriculum changes more aligned to the Common Core State Standards.*

Initial and ongoing focus on curriculum: Teacher teams developed — and continue to refine — a district curriculum, known as instructional guides, that integrates NGSS concepts and practices. This includes a collection of sample performance tasks to show what NGSS and CCSS-aligned STEM student work looks like.

Investment in strategic professional development: Site-level curriculum specialists are released from classroom assignments to lead weekly and monthly professional learning communities for instructional planning purposes. District-level curriculum specialists strategically group these site-level specialists for district trainings by combining staff from schools serving students of varying poverty levels in order to create common expectations and outcomes regardless of student background.

COACHELLA VALLEY UNIFIED SCHOOL DISTRICT *is a district of 20,000 students in Riverside County. Nine in 10 students are low income, almost all are Latino, and 65 percent of students are learning English — almost three times the state average of 22 percent. CVUSD's shift to NGSS began almost two years ago as part of a grant proposal.*

Intensive focus on teacher professional development: The district has identified professional development as a key lever in building its capacity to implement NGSS. In fact, it is a central component of Project Prototype, a three-year Mathematics and Science Partnership grant[39] with two other districts in the valley. Currently in the first grant year, the district is working to uncover the challenges teachers are likely to encounter in NGSS implementation.

Increasing teachers' engineering content knowledge: Recognizing that the engineering component of NGSS represents a particularly challenging shift for teachers, CVUSD has partnered with professors from area universities who work with teachers to, for example, vet potential classroom engineering projects. Through Project Prototype, the district is also partnering with local industry leaders to learn about the real-world applicability of the standards while also providing teachers with lesson ideas.

HACIENDA-LA PUENTE UNIFIED SCHOOL DISTRICT, *just 20 miles east of downtown Los Angeles, serves 20,000 students. Eighty percent of students are Latino,12 percent are Asian, 77 percent are low income.*

Technology-focused professional development and support: To encourage student interest in STEM before high school, the district developed a pilot STEM course at all middle schools, guiding students through computer-based units utilizing classroom laptop carts. To prepare teachers for this shift, all teachers engaged in three days of professional development around this new technology. The district also formed PLCs that provided paid afterschool time for teachers to plan and learn together. Classroom teachers were supported throughout the year by teachers on special assignment, who focus on science and technology, to build educator capacity and help them feel comfortable with the new tools.

Building teacher capacity for STEM learning in the early grades: School leaders are working with elementary teachers to make learning more interdisciplinary and to make more thoughtful connections between STEM and literacy in particular. For example, second grade teachers at one site read the fairytale "Rapunzel" and then challenged students to build the tallest tower using various materials. Doing so provided an opportunity for classes to discuss the engineering practices included in NGSS, an area few teachers at that grade level had previously taught.

OUR RECOMMENDATIONS

The evidence is clear: Low-income students and students of color do not have enough access to the qualified STEM teachers and rich learning opportunities they deserve. Fortunately, state and local leaders can take action to change the tide for California's students.

WE PROPOSE THE FOLLOWING RECOMMENDATIONS FOR STATE LEADERS:

1. **Increase the pipeline of teachers entering the STEM teaching profession.** Various state and federal initiatives, like 100Kin10 and the California State University's Math and Science Initiative,[40] have worked to increase the number of STEM teachers. The state should build on these efforts, using a broader communications strategy, particularly in coordination with institutions of higher education, to encourage young people and STEM majors to consider teaching as a viable career option. The state should also think about creating additional grant programs that subsidize tuition for teacher candidates pursuing authorizations in STEM, similar to the National Science Foundation's Noyce Fellowship program. Another potential approach would be to repay loans for students who commit to teach in hard-to-staff subjects and high-need schools — like the state's currently defunded Assumption Program of Loans for Education (APLE). In addition, priority for financial assistance should be given to teacher candidates willing to teach in both high-need schools *and* hard-to-staff subject areas such as STEM. Finally, the state should support efforts to encourage mid-career STEM professionals to enter the teaching profession, similar to the work of the nonprofit EnCorps.

2. **Provide districts with an additional infusion of professional development dollars specifically targeted toward Common Core and Next Generation Science Standards implementation.** The professional development needs associated with implementing California's new standards are enormous and warrant investments beyond what the state has already committed. These resources should allow for long-term, sustained professional development opportunities to ensure teachers are adept at providing standards-aligned STEM learning opportunities. When awarding one-time funds for standards implementation, policymakers should equitably distribute these funds based on district needs, and they should require that districts share their plans for these dollars in their Local Control and Accountability Plans.

3. **Strengthen credentialing programs.** California needs to require a more rigorous base level of content knowledge or a minimum number of undergraduate or similar content courses prior to trainees enrolling in a teacher credentialing program. The state should ensure that all trainees — including those preparing to teach at the elementary level — are exposed to STEM content in credentialing programs that is relevant to their subject matter and aligned with the NGSS. In addition, credentialing programs need to integrate content and pedagogical training within the curriculum. If all teaching candidates enter credentialing programs with a base level of math and science content knowledge and they participate in a more rigorous and aligned training program, they will be better prepared to teach their subject area.

4. **Develop better, more synchronized teacher data systems.** The state's inadequate teacher data systems make it difficult to tell where we have teacher shortages. The state should create links between the California Commission on Teacher Credentialing data systems that track credentials and the California Department of Education's data systems[41] that track actual teachers by placement and credential(s) possessed. In doing so, stakeholders would be able to understand the extent to which preparation programs are meeting local demand.

WE PROPOSE THE FOLLOWING RECOMMENDATIONS FOR SCHOOL DISTRICTS AND/OR INSTITUTIONS OF HIGHER EDUCATION:

1. **Develop incentive systems to attract and retain high-quality STEM teachers, particularly in high-need schools.** The Local Control Funding Formula affords districts more flexibility to consider new incentive strategies. For example:

   a) Create differentiated pay scales for hard-to-staff subjects like STEM. Doing away with traditional pay scales that confine teachers to step-and-ladder increases in salary can help attract qualified math and science professionals to teaching.

   b) Give principals in high-need schools hiring priority for STEM teachers and other in-demand teacher positions. Leaders from the highest need schools should be the first allowed to select STEM teachers from the candidate pool. Doing so will give school leaders in high-poverty and underperforming schools the ability to choose the highest quality teachers for the students who need them most.

   c) Offer STEM teachers additional training and collaboration opportunities. Establish relationships with institutions of higher education and industry leaders to access faculty and professionals offering trainings on the most current developments and real-world topics, similar to the district "bright spot" examples highlighted in this report.

2. **Ensure a strong system of educator professional development, especially for new STEM teachers.** With access to induction programs during the early stages of their careers, new teachers can refine their craft. And with access to mentors, they are less likely to leave the classroom early in their teaching careers. A strong system of professional development should build sustained capacity locally by including opportunities for job-embedded development at all stages of teachers' careers. Partnerships with nonprofit organizations like the New Teacher Center that develop and implement induction and professional development programs can help facilitate these types of supports. Evaluate where previous professional development investments have been ineffective and consider replacement units, a model of instructional reform proven to increase student learning by changing teacher practices.[42] Invest in science and math specialists to provide ongoing coaching for all teachers, and utilize resources like those offered by the California Subject Matter Project[43] to build teacher leadership and create collaborative networks between teachers and university faculty. Empower teachers to learn and plan together in teams by creating time and space within the school day to collaborate.

3. **Establish strong partnerships with teacher preparation programs and other community partners.** Relationships between districts and institutions of higher education will ensure candidates are exposed to clinical practice during their training, encourage communication between districts and preparation programs to understand how candidates are performing, and strengthen the teacher-to-school pipeline. Preparation programs and districts should also work with local businesses and industry partners to encourage mentorships, apprenticeships, guest teaching by STEM experts, and other real-world learning opportunities for students.

CONCLUSION

When it comes to providing high-quality STEM instruction that meets the needs of all students, California has much work to do. The newly adopted science and math standards and the exciting opportunities for classroom innovation that they bring can only be realized if we ensure our students have sufficient access to high-quality math and science teachers. But we have a STEM teacher shortage, which will only become more dire if state agencies, institutions of higher education, and districts don't take immediate action. Our state has an obligation to ensure all California students have access to qualified, well-prepared, effective STEM teachers and to support educators to teach our students to the highest standards. In doing so, we can begin to close the inexcusable STEM learning gaps that currently plague our schools.

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TECHNICAL APPENDIX: DATA SOURCES, CALCULATIONS, AND METHODOLOGY

TEACHER SUPPLY AND DEMAND ANALYSIS

TEACHER "DEMAND" CALCULATION: First, we calculated the number of teacher vacancies districts projected for the 2013-14 school year. To do this, we downloaded the 2012-13 CBEDS Data About Schools/Districts file on 7/10/15 from the California Department of Education website at http://www.cde.ca.gov/ds/sd/sd/filescbedsorab.asp. This file contains estimated teacher hires for the following school year by subject area ("description"). We then summed the number of teachers districts projected they would need by subject area to arrive at the projected demand for math and science teachers for the 2013-14 school year.

TEACHER "SUPPLY" CALCULATION: Next, we calculated the number of math and science teachers actually hired in the 2013-14 school year. To do this, we downloaded the 2013-14 Staff Assignment file on 7/10/15 from the CDE website at http://www.cde.ca.gov/ds/sd/df/filesassign.asp. This file contains teaching assignment course codes for individual teachers along with their estimated full-time equivalent assignments. We then linked the total number of years taught and the total number of years in teachers' current districts from the 2013-14 Staff Demographics file (accessed on 5/15/15 at http://www.cde.ca.gov/ds/sd/df/filesstaffdemo.asp) via individual teacher record identification numbers. We also linked assignment subjects from the Assignment Codes 2012-13 On file (accessed on 5/21/15 at http://www.cde.ca.gov/ds/sd/df/filesassign.asp) to course codes to determine which teachers taught math and/or science in 2013-14. We then summed the estimated FTE for every STEM teacher in order to identify those teachers with a full teaching load in math and/or science. When calculating the number of newly hired math and science teachers for 2013-14, we only included those teachers with an estimated FTE of .96 for math and/or science who were new to the district in 2013-14 (regardless of previous experience). We selected this .96 cutoff because of trends in how FTE percentages were assigned based on differences in course loads.

SUPPLY-DEMAND GAP CALCULATION: We calculated the gap between supply and demand of STEM teachers by subtracting the Number of New District Hires in 2013-14 from the Number of New Teachers Needed based on 2012-13 projections. We then divided the sum of new hires by the sum of vacancies to arrive at the percent of demand met.

SUPPLY-DEMAND DISAGGREGATION: We then disaggregated the supply-demand data in order to estimate the percentage of teacher need met by various district characteristics: district type, poverty level, and locale. To do so, we linked the following data points:

- Total teacher "demand," as described above
- Total teacher "supply," as described above
- District type (see description below)
- District poverty quartile (see description below)
- District locale (see description below)

DISTRICT TYPE: We downloaded the Public Schools Database file on 7/15/15 from the CDE website at http://www.cde.ca.gov/ds/si/ds/pubschls.asp. This allowed us to identify each Local Education Agency by type and flag those LEAs as unified, high school, or elementary districts, or county offices of education. We filtered out all other LEA types. We included charter schools with their authorizing district or county office of education.

FREE OR REDUCED PRICE MEAL (POVERTY) RATES AND QUARTILES: We downloaded the 2013-14 Unduplicated Student Poverty – Free or Reduced Price Meals Data file on 6/6/15 from the CDE website at http://www.cde.ca.gov/ds/sd/sd/filessp.asp. We summed school-level K-12 enrollment and adjusted K-12 FRPM count to the LEA level and divided these LEA-level FRPM counts by the total LEA K-12 enrollment counts to calculate FRPM rates by LEA. We then created poverty quartiles such that districts fell into the low, middle, or high-poverty categories. The bottom poverty quartile represents the 25 percent of districts with the lowest percentage of students who are eligible for FRPM, the top poverty quartile represents the 25 percent of districts with the highest percentage of students eligible for FRPM, and the middle poverty quartiles represent the middle 50 percent of districts. The poverty quartiles broke out as follows: Lowest poverty quartile = 0 to 38.3 percent FRPM, middle poverty quartiles = 38.4 to 77.3 percent, and highest poverty quartile = 77.4 to 100 percent.

DISTRICT LOCALE: We downloaded the 2005-06 (latest year available) Local Education Agency (School District) Locale Code file on 7/14/15 from the National Center for Education Statistics' Common Core of Data website at https://nces.ed.gov/ccd/CCDLocaleCodeDistrict.asp. We combined the 12 urban-centric locale codes into four categories — city, suburb, town, and rural — by collapsing the three sub-categories of each (i.e., city: large, city: mid-size, city: small), such that each LEA was associated with one of these four categories.

HIGH SCHOOL TEACHER CREDENTIALS ANALYSIS

MATH TEACHER CREDENTIAL TYPE CALCULATION: We downloaded the 2013-14 Staff Credential file on 7/13/15 from the CDE website at http://www.cde.ca.gov/ds/sd/df/filesstaffdemo.asp. We linked credential codes to all teachers from the Staff Assignment file, and we linked each of these teachers to a school using the Public Schools Database file. We filtered for teachers whose assignment subject is math, who teach full time in this assignment area, and who teach in high schools (school code #66). We then determined whether each teacher had a math authorization (authorization type #200 or #280), and whether each teacher had a full credential (credential type #10). We flagged each teacher as either "math authorized" or "not math authorized" and as "fully credentialed" or "not fully credentialed."

SCIENCE TEACHER CREDENTIAL TYPE CALCULATION: We downloaded the 2013-14 Staff Credential file on 7/13/15 from the CDE website at http://www.cde.ca.gov/ds/sd/df/filesstaffdemo.asp. We linked credential codes to all teachers from the Staff Assignment file, and we linked each of these teachers to a school using the Public Schools Database file. We filtered for teachers whose assignment subject is science, who teach full time in this assignment area, and who teach in high schools (school code #66). We then determined whether each teacher had a science authorization (authorization types #130, #140, #160, #170, #190, #210, #220, #270, #310, #320, or #330), and whether each teacher had a full credential (credential type #10). We flagged each teacher as either "science authorized" or "not science authorized" and as "fully credentialed" or "not fully credentialed."

HIGH SCHOOL MATH AND SCIENCE TEACHER CREDENTIAL BY DISTRICT POVERTY QUARTILE CALCULATION: We created four categories — fully credentialed/math (or science) authorization, fully credentialed/no math (or science) authorization, not fully credentialed/math (or science) authorization, not fully credentialed/no math (or science) authorization — and assigned each high school teacher to one of these categories based on his or her credential and authorization status. We also linked previously referenced poverty quartile by district data to each teacher, allowing us to sum the number of teachers in each of the four categories by poverty quartile. Finally, we divided each of these totals by the sum of teachers in each poverty quartile to arrive at the percent of teachers in each poverty quartile that fall into each of the four categories. This allowed us to determine the ratio of fully credentialed, STEM-authorized teachers to the other three categories in order to determine the likelihood that students in the highest versus lowest poverty districts would be taught by one of these types of teachers.

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Suburb: Territory outside a principal city and inside an urbanized area.
Town: Territory inside an urban cluster.
Rural: Census-defined rural territory.
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OUR MISSION

The Education Trust–West works for the high academic achievement of all students at all levels, pre-k through college. We expose opportunity and achievement gaps that separate students of color and low-income students from other youth, and we identify and advocate for the strategies that will forever close those gaps.

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The Education Trust–West

1814 Franklin Street, Suite 220 | Oakland, California 94612 | 510.465.6444

www.edtrustwest.org