Chapter 10
Access and Equity

2016 Science Framework

FOR CALIFORNIA PUBLIC SCHOOLS
Kindergarten Through Grade Twelve

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Items in this document that relate to crosscutting concepts are highlighted in green and followed by the abbreviation CCC in brackets, **[CCC]**, with a number corresponding to the concept. The same items that correspond to the science and engineering practices are highlighted in blue and followed by the abbreviation SEP in brackets, **[SEP]**, with a number corresponding to the practice.

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Access and Equity

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California's Diversity

California's children and youth bring to school a wide variety of skills and abilities, interests and experiences, and cultural and linguistic resources from their homes and communities. The greater the diversity in classrooms and schools, the richer the learning experiences for all, and the more assets upon which teachers may draw for science and engineering learning. At the same time, however, the teacher's role becomes more complex in providing high-quality curriculum and instruction that is sensitive to the needs of individual students and leverages their particular assets. In such complex settings, the notion of shared responsibility is critical. Teachers, administrators, specialists, expanded-learning leaders, families, and the broader school community need the support of one another in order to best serve all students.

The California Next Generation Science Standards (CA NGSS) call for science teachers to provide all students access to a rich and engaging curriculum that is appropriately challenging. Responding to this call requires that educators share the responsibility of ensuring equity for several populations of learners who are particularly vulnerable to academic inequities in science and engineering (see Equity and the NGSS below). With over 60 languages other than English spoken by California's students, there is a rich tapestry of cultural, ethnic, and religious heritages students enjoy, and a range of skill acquisition, physical abilities, and circumstances that impact students' lives and learning. Highlighted here are some groups of students for whom it is important to acknowledge and value the resources and perspectives that they bring to school, as well as the specific learning needs that must be addressed in classrooms, so that students who are members of these groups can achieve their full potential in science and engineering. These groups are identified so that schools and districts make critical systems shifts to ensure educational access and equity for all students.

Equity and the CA NGSS: A Shared Responsibility

Educational equity is a shared responsibility, and collaboration is essential for achieving it. Teachers are at their best when they collaborate with their teaching colleagues to plan science, technology, engineering, and mathematics (STEM) instruction; analyze student work; discuss student progress; integrate new learning into their existing practice; refine lessons; and identify alternative approaches when students experience, or need, additional challenges. Students are at their best when teachers enlist the collaboration of parents, families, and communities as partners in education. Schools are at their best when all educators in the school community are supported by school and district leaders to implement the type of instruction called for by the CA NGSS. Districts are at their best when teachers, specialists, and leaders across the district engage in an expanded professional learning community they can rely upon as thoughtful partners and for tangible instructional resources.

The following groups of students are discussed in this chapter:

- Standard English learners
- English learners
- Ethnically diverse learners
- Students living in poverty
- Foster youth
- Girls and young women (gender equity)
- Advanced learners and gifted learners
- Students with disabilities
- Students experiencing difficulties with literacy in science and engineering

For an expanded discussion on California's diverse student population, including lesbian, gay, bisexual, and transgender students; biliterate students; and students who are deaf, see California's *English Language Arts/English Language Development Framework* (CDE 2014a).

Though presented separately, these populations are not mutually exclusive; many students are members of multiple groups. Furthermore, it is important that, while teachers inform themselves about particular aspects of their students' backgrounds, they should remember that each population is a heterogeneous group. Therefore, teachers should take steps to know their students as individuals.

A major goal of this *CA Science Framework* is to help alleviate the inequities that have prevented a large number of California's children and youth from excelling in science and engineering. Throughout this framework, guidance is provided to help schools and districts implement intellectually rich, relevant, and engaging science and engineering programs, courses, and pedagogy to ensure that classrooms are supportive, inclusive, and inspiring for all students. The vision of the CA NGSS is "all standards, all students." Science and engineering education should be designed and taught in such a manner that every student, regardless of background or learning characteristics, has access to and benefits from deep and engaging science and engineering learning opportunities. Appendix K of the CA NGSS discusses the equity-oriented stance taken when developing these standards and presents a set of classroom vignettes from work undertaken by teacher members of the NGSS Equity team to demonstrate how these standards can be used to provide learning opportunities for a wide diversity of students.

This chapter addresses particular steps that educators can take to ensure students' full access to the CA NGSS and provide a strong focus on equity in the science and engineering curriculum, instruction, and programs so that all California students can achieve their full potential. The chapter begins by recognizing who California's students are, including their many layers of diversity, and then offers guidance on designing and implementing science and engineering curriculum and instruction that is responsive to this diversity.

California enjoys one of the most diverse student populations in the nation. This rich diversity offers an invaluable resource for creativity, innovation, and global leadership in science and engineering. At the same time, diverse student populations present challenges as teachers seek to ensure that each of their students

- develops the knowledge, conceptual understandings, and habits of mind to engage in the study of science and engineering;
- becomes a science-literate member of society;
- develops the interest and ability to engage in further learning about these subjects as life-long learners; and
- considers careers that require these abilities.

All students are capable of understanding and fully engaging in science and engineering, and it is critical for all schools to ensure that every student has full access to appropriate and equitable learning opportunities to accomplish this goal. It is important to acknowledge persistent inequities in enrollment, retention, and achievement in high-quality science and engineering programs.

There is growing evidence that the intentional integration of art and design with STEM disciplines, or science, technology, engineering, arts, and mathematics (STEAM), develops students' motor, decision-making, and problem-solving skills. Connecting STEM instruction to the arts and design can spark creativity for teachers and students alike. Teachers can meaningfully and authentically integrate arts standards in STEM lessons and projects where the standards most naturally align (Riley 2013; Jolly 2014). Embracing the principles of art and design can also serve students as they tackle engineering challenges, develop creative solutions, and express what they are learning in engaging, innovative ways. The diverse populations of learners who may be particularly vulnerable to academic inequities in science and engineering stand to benefit from engagement in the arts. Building in opportunities in STEM classes to develop and use the principles, skills, and ingenuity of the arts can "serve as an on-ramp for STEM success for underrepresented students. Engaging students' strengths using art activities increases motivation and the probability of STEM success" by "offering more diverse learning opportunities and greater access to STEM for all types of learners" (Jolly 2014).

A study by the National Endowment for the Arts (2012) states that socially and economically disadvantaged children and teenagers who actively engaged in the arts were more likely to participate and succeed in school, graduate from high school, and enroll in college.

Americans for the Arts compiles data that shows that children and youth participating regularly in the arts, regardless of their socioeconomic status, develop skills that transfer to other content areas; they also tend to have improved academic performance and lower drop-out rates (access Americans for the Arts research reports at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link1).

These inequities particularly affect students of color, students with disabilities, girls and young women, English learners (ELs), foster youth, and students living in poverty. Among this population, some students have limited access to science instructional time, well-prepared science and engineering teachers, high-quality science and engineering curriculum and programs, effective science and engineering instruction, space and resources for engagement in science and engineering practices with real materials, and other educational resources. Other students receive implicit and explicit messages in school that prompt them to be less inclined to engage in science and engineering than other groups of students. Still others may experience a low level of acceptance and safety in schools because of their cultural, ethnic, and linguistic background; disability; sexual orientation; socio-economic status; or other reasons. The following are some critical actions for ensuring equity in science and engineering.

Ensuring Equity in Science and Engineering: Critical Actions

Maintain Appropriate Programs and Physical Resources

- Maintain high-quality, discipline-relevant, and up-to-date instructional materials.
- Maintain appropriate equipment, including up-to-date and relevant science lab and engineering equipment and technology resources, including computers and appropriate hardware.
- Maintain safe and appropriately designed facilities,[1] including suitable spaces for CA NGSS-based science and engineering tasks and uncrowded classrooms.
- Ensure all students have access to CA NGSS-aligned science and engineering programs and courses taught by highly skilled teachers licensed in their subject area.

Implement Equity-Focused Practices

- Collaborate within and across disciplines and specialized areas (including STEM and other content areas, English language development (ELD) teachers, special education specialists, and education support professionals).
- Know each student's learning strengths and needs, and design instruction accordingly.
- Infuse pedagogy with techniques that inspire students, including engaging projects and hands-on experiences.
- Encourage and support discussion (student-student, teacher-student) about science and engineering topics where all voices are included.
- Integrate a focus on disciplinary literacy and language development in the service of science and engineering learning.

Establish Positive, Bias-Free Learning Environments

- Recognize and address biases and inequities and support students to do the same.
- Create and sustain "growth mindset" learning environments that support students' positive attitudes toward, persistence in, and self-efficacy in science and engineering courses.
- Integrate culturally and linguistically responsive pedagogy and promote an "additive stance" toward diversity.
- Initiate respectful and positive teacher-to-student interactions, and inspire students to see themselves as scientists and engineers,
- Initiate respectful interactions with students' parents and guardians, and encourage families to support their children as successful scientists and engineers.

1. For detailed information, see the Science Safety Handbook for California Public Schools, 2014 Edition (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link2).

Inequities in science and engineering, and related and interacting inequalities in access to advanced mathematics, have severely undermined the ability of two particular groups of students—students living in poverty and students of color—to pursue STEM careers.

Promote STEM Equity for Students Living in Poverty and Students of Color

"California's population is highly diverse, yet it is known that students living in poor urban or rural areas and many students from underrepresented groups lack access to high-quality STEM education. This has resulted in lack of proficiency that disproportionately impacts students of color.

The state has not closed the persistent achievement gap among racial and ethnic groups in math and science. . . . On the grade eight NAEP science assessment, only 22 percent of California students tested proficient or above, and 47 percent tested below basic in science. In 2011, 39 percent of white eighth-graders reached the proficiency level in science while only 8 percent of African American students and 11 percent of Hispanic students reached that level (National Assessment of Educational Progress [NAEP] 2013).

One consequence of California's lack of access to STEM education for all students is that the STEM workforce does not reflect the demographics of the state. This is also true at the national level; minorities continue to be underrepresented in STEM occupations relative to their position in the labor market as a whole."

Source: California Department of Education (CDE) 2014b.

Standard English Learners

Standard English learners (SELs) are native speakers of English who are ethnic minority students (e.g., African American, American Indian,[2] Southeast Asian American, Mexican American, Native Pacific Islander) *and* whose mastery of the standard English (SE) language and academic use of English, which is typically given higher status in schools, is limited; this limitation may occur because they use an ethnic-specific *nonstandard* dialect of English in their homes and communities and in communities where SE or academic English are used in limited ways[3] (LeMoine 1999; Okoye-Johnson 2011).[4] The term *standard English* is used to identify one variety of English among many. The *American Heritage Dictionary of the English Language* defines standard English as "[t]he variety of English that is generally

2. Other terms used include Native American and First Nations. The recommended approach is to refer to the tribe if that information is known.
3. Some researchers have also identified as SELs students who are not ethnic minorities but who experience intergenerational poverty and therefore have not had opportunities to develop SE in their home and community environments.
4. An alternate definition of SELs are "those students for whom Standard English is not native and whose home language differs in structure and form from Standard and academic English" (*LAUSD English Learner Master Plan* 2012).

acknowledged as the model for the speech and writing of educated speakers, especially when contrasted with speech varieties that are limited to or characteristic of a certain region or social group." The term *educated* should be used to describe a person who has gone through advanced levels of education—where knowledge is developed through reading and writing academic texts, engaging in discussions about academic content, and participating in academic tasks—and not equated with *intelligent*. Also note that there is no universal definition for SE, as it is "highly elastic and variable" with "inconvenient ambiguities that are inherent in the term" (*The American Heritage Dictionary of the English Language*).

Teachers can support their students in understanding that the way English is used varies depending on audience, topic, content, mode of communication, and purpose for communicating (e.g., to argue, explain, or describe). The way students use everyday language and home dialects interacting with their families or engaging in science inquiry tasks with their peers is different from the type of language expected in certain academic tasks, such as engaging in a formal classroom debate about the use of animals in science experiments or writing an argument about the effects of climate change. Students may experience challenges achieving in science and engineering learning experiences if they are unaware of the different expectations for language use in different situations and do not have the opportunity to learn the language of science and engineering.

Indeed, developing facility with the language used in science and engineering is likely a challenge for all students. This disciplinary science and engineering language includes specialized vocabulary, including domain-specific vocabulary (e.g., mitosis, atom), general academic vocabulary (e.g., significance, verify), and familiar words that take on new meaning in science (e.g., volume, matter, theory). It also includes particular ways of structuring phrases, sentences, and larger bodies of text that are specific to the disciplines of science and engineering; these are unlikely to be familiar to children and youth from any home background. All students need multiple and varied opportunities to learn and use, in meaningful ways, the specialized language of science; this attention to language supports students' conceptual understandings and their ability to engage in deeper inquiry in science and engineering. In addition, students need explicit instruction in the norms of how to interact in extended academic discussions. These ways of interacting include initiating or entering a conversation, building on the ideas of others, respectfully disagreeing, and questioning assertions. All of these tasks that are integral to deeper science and engineering learning are language—and literacy—intensive. To achieve equity and access in science learning environments, teachers need to find ways of supporting SELs (along with all other students) to develop this specialized language and understand how and when to use it appropriately. This includes drawing all students' attention to the language of science and engineering and strategically structuring opportunities for students to develop proficiency with disciplinary literacy. (For more on disciplinary literacy, see chapter 11 on instructional strategies in this framework.)

For all students to engage in science and engineering practices, teachers should also establish classroom norms for inclusive discourse and student contributions. The language students use when engaged in conversations about science and engineering should be accepted—and, indeed, encouraged—for the *ideas* that students bring, regardless of the style of English in which these ideas are articulated. The purpose of facilitating students' engagement in science and engineering discourse is not to *correct* the student's language or compel students to use particular words or phrases, but to develop and enrich student language through its purposeful use in intellectually rich and meaningful experiences. With this focus on meaning and on language as a meaning-making resource, all students are supported to develop the ability to discuss science. As students espouse the academic language of science, they will increasingly make informed decisions about the language they encounter when they read or employ in their discussions, presentations, and writing. The goal is to support all students to develop new ways of using language and to understand how to make intentional language choices so that they are able to flexibly shift *register*[5] to meet the language expectations of a variety of science and engineering tasks.

The next section focuses specifically on two of many dialects of English used by SELs (and also by proficient users of SE as a sign of solidarity with their community): African American English (AAE) and Chicana/Chicano English (CE). Although AAE and CE speakers are highlighted here, recommendations for how teachers should perceive language diversity and approach the learning of SE and the disciplinary language of science apply to all groups of SELs. (See also the section on culturally and linguistically relevant teaching elsewhere in this chapter.)

African American English Speakers

African American English (AAE)—also termed African American Vernacular English, African American language, Black English Vernacular, Black Language, Black Dialect, or U.S. Ebonics (Chisholm and Godley 2011; Perry and Delpit 1998)—may be spoken by SELs and by proficient SE speakers alike, who may choose to use AAE as a sign of affiliation and solidarity with their community and/or family. African American English speakers who are

5. *Register* refers to the ways in which grammatical and lexical resources are combined to meet the expectations of the context (i.e., the content area, topic, audience, and mode in which the message is conveyed). See figure 2.14 in the *ELA/ELD Framework* for more information on *register.*

able to *code-switch* (shift between different languages or varieties of English) can flexibly shift the variety of English they use, adjusting it to the expectations of particular discourse communities such as work, school, family, and peers.

African American English has inaccurately been perceived by some teachers as ungrammatical or illogical, which has led some teachers to view their students who use AAE as less capable than SE speakers (Chisholm and Godley 2011). These assumptions, often made unconsciously, are unfounded and, if left unexamined and unchecked, create negative learning environments for African American children and youth (Flemister-White 2009). Like all other natural linguistic systems, AAE is governed by consistent linguistic rules and has evolved based on historical and cultural factors. AAE is fully capable of serving all of the intellectual and social needs of its speakers (Trumbull and Pacheco 2005). Instead of viewing AAE as subordinate or inferior to SE, a more accurate perspective and productive approach would be to view AAE as a cultural and linguistic resource, and like all cultural and linguistic resources, AAE should be seen as an asset to be valued in its own right, leveraged for further learning, and a foundation for adding new language resources, including the disciplinary language of science.

Chicana/Chicano English Speakers

Some Mexican Americans and other Latinas/Latinos who live in predominantly bilingual social settings may speak Chicana/Chicano English (CE). Chicana/Chicano English has been described as a nonstandard variety of English, influenced by contact with Spanish, and spoken as a native dialect of English (Fought 2003). In many ways, CE represents the linguistic history of Mexican American and other Latina/Latino people as the dialect emerges from the linguistic setting where there is contact between Spanish and English. Languages naturally change as they come in contact with one another over a long period of time.

Chicana/Chicano English is not simply English influenced by Spanish or English with an accent, as it is often mistakenly thought to be. In addition, CE is sometimes erroneously considered to be ungrammatical. As is the case with AAE, CE is an independent, systematic, and rule-governed language variety (or dialect of English) that bilingual and/or bi-dialectal people may deliberately choose to use as a sign of solidarity with their community and/or as an active marker of their identity.

Some CE speakers may have a high level of language proficiency in Spanish, depending on their family and life history. However, many CE speakers in California are monolingual English speakers, and CE may be the first and only variety of English they are exposed to in childhood. In the case of bilingual speakers of CE, some of these speakers may have limited proficiency in Spanish and are English-dominant. They may be able to understand some spoken Spanish, and they may also have some Spanish language skills such as commands, certain vocabulary terms (especially taboo terms), and basic social Spanish (Fought 2003).

The framing of nonstandard dialects of English as cultural and linguistic assets positions traditionally nondominant language speaking students as learners who are fully capable of participating in and benefiting from an intellectually rich science curriculum. This perspective—one that both *acknowledges* all of the cultural and linguistic contexts in which students learn and live and *seeks to understand* the relationship between language, culture, identity, and learning—promotes positive relationships and improves educational outcomes. There are many other examples of nonstandard varieties of English (e.g., New York Latino English, Hawaiian Creole English) and regional dialects of English (e.g., Southern English), that are not elaborated upon in this section.

Because so much STEM learning occurs through oral and written discourse (including discussions, presentations, and many different types of writing), these understandings about language diversity, including nuanced understandings of dialect differences, are critical for STEM teachers to develop. Classrooms should be spaces where students can use both the language they bring from their homes and communities and also develop new ways of using the more specialized language of STEM fields.

English Learners

Students who are learning English as an additional language come to California schools with a range of cultural and linguistic backgrounds, proficiencies in English, and experiences with formal schooling and content learning (both formal and informal). Many ELs in California were born in the U.S. and have only experienced schooling in English. Other ELs enter the U.S. in late elementary through high school and may have strong academic backgrounds, be on par with their native-English speaking peers in terms of content knowledge, and have studied English in their home countries before emigrating. Other ELs have had disrupted educational experiences due to a variety of reasons, including war, persistent violence, or famine in their home countries or because severe poverty, cultural norms, or political factors prevented them from attending school.

However, along with their linguistic background, ELs come to the classroom with rich life experiences. They use their experiences to create personal explanations about how the natural world operates. Therefore, although a student may not possess the language to express these ideas, all students have a wealth of scientific ideas and explanations to contribute to discussions and learning tasks.

All of these factors inform how educators should design and implement science and engineering instruction so that ELs achieve success. All teachers are responsible for ensuring that their EL students have full access to an intellectually rich and comprehensive science and engineering curriculum and that all EL students make steady progress in both their academic content learning and their English language development. With appropriate scaffolding from their teachers and appropriately designed programs, ELs at all levels of English language proficiency are able to engage in intellectually challenging, content- and language-rich instruction so that they can develop the advanced levels of English and content knowledge necessary for college and career readiness and meaningful engagement with civic life.

English learners are defined by the California Department of Education (CDE) as those students for whom there is a report of a primary language other than English on the state-approved Home Language Survey ***and*** *who, on the basis of the state approved oral language (grades kindergarten through grade twelve) assessment procedures and literacy (grades three through twelve only), have been determined to lack the clearly defined English language skills of listening comprehension, speaking, reading, and writing necessary to succeed in the school's regular instructional programs.* (CDE 2016)

The needs of ELs are best met when English language and content areas are addressed in concert (Lee and Luykx 2005). This is why all science teachers of ELs should use the California English Language Development Standards (CA ELD Standards), in tandem with the CA NGSS and the CA CCSS for ELA/Literacy, to fully include ELs in science and engineering instruction. Assembly Bill 899 (October 2013) required the CA ELD Standards be comparable in rigor and specificity to the California Common Core State Standards for Mathematics (CA CCSSM) and the CA NGSS. To meet the requirements of the legislation, the CDE, in collaboration with WestEd and a panel of experts, created a document, *Integrating the CA ELD Standards into K–12 Mathematics and Science Teaching and Learning* (Lagunoff et al. 2015). The supplementary resource provides illustrative examples of the tandem implementation of the CA ELD Standards with the CA NGSS and CA CCSSM.

This integrated approach, in which science teachers provide ELs support for academic language development during science instruction, can lead to increased student performance in writing, reading, and science understanding (Stoddart et al. 2002; Lee et al. 2005; Lee et al. 2008). For example, research on programs that utilize inquiry science to support English language development (ELD) demonstrates that EL students develop English more rapidly on both ELD and ELA measures when compared to students participating in ELD programs only (Gomez-Zwiep and Straits 2013; Shea et al. 2012). In particular, participation in such programs appears to have a positive effect on students' oral language development.

While learning an additional language is multilayered and complex, is dependent upon many interrelated variables, and typically does not occur in a linear fashion, there are some general stages of ELD. California refers to these general stages as *Emerging, Expanding, and Bridging.*[6] The CA ELD Standards offer guidance on providing appropriately designed instruction at these three stages by providing outcome statements for the culmination of each stage. Table 10.1 summarizes the general progression of ELD as conceptualized in the CA ELD Standards, along with acknowledgment that ELs bring language with them when they enter schools (their native language) and become lifelong language learners once they become reclassified as proficient in the English language.

6. Note that the terms *beginning, early intermediate, intermediate, early and advanced, advanced* to describe English language proficiency levels have been replaced with *Emerging, Expanding, Bridgin*g.

Table 10.1. English Language Proficiency Levels

→→→→→→→→→→→→→→→→→→→ **ELD CONTINUUM** →→→→→→→→→→→→→→→→→→→

(Arrows show a progression from beginning to advanced levels of English proficiency.)

Native Language	Emerging	Expanding	Bridging	Lifelong Language Learners
ELs come to school with a wide range of knowledge and competencies in their primary language, which they draw upon to develop English.	ELs at this level typically progress very quickly, learning to use English for immediate needs as well as beginning to understand and use academic vocabulary and other features of academic language.	ELs at this level increase their English knowledge, skills, and abilities in more contexts. They learn to apply a greater variety of academic vocabulary, grammatical structures, and discourse practices in more sophisticated ways, appropriate to their age and grade level.	ELs at this level continue to learn and apply a range of advanced English language knowledge, skills, and abilities in a wide variety of contexts, including comprehension and production of highly complex texts. The bridge alluded to is the transition to full engagement in grade-level academic tasks and activities in a variety of content areas without the need for specialized instruction.	Students who have reached full proficiency in the English language, as determined by state and/or local criteria, continue to build increasing breadth, depth, and complexity in comprehending and communicating in English in a wide variety of contexts.

EL students, at any given point along their trajectory of English language development, may exhibit some language abilities (e.g., speaking skills) at a higher proficiency level, while at the same time exhibiting other abilities (e.g., writing skills) at a lower proficiency level (Gottlieb 2006). Thus, students may understand much more than they can express. Other students may successfully perform particular skills at a lower English language proficiency level (e.g., reading and analyzing a science text), and at the next higher proficiency level, they may need review in the same reading and analysis skills when presented with a different, or more complex, type of text.

All K–12 teachers who teach science and engineering to ELs should ensure that ELs have full access to a robust science curriculum and develop advanced levels of English in science in a timely manner. This can only be done through careful lesson and unit planning (using the CA ELD Standards), observation of what students are doing and saying during science instruction, reflection on how ELs engage with particular approaches to instruction, and necessary refining and adjusting of instruction based on observation and reflection. Critically, schools and districts should ensure that EL students are not deprived of science learning opportunities by placement in an ELD class during *science time*.[7] Indeed because of the focus on real materials and activities, not to mention the high-interest topics and potential for disciplinary language-rich discussions, science and engineering classes are ideal learning environments for *integrated* English language development. For this reason, STEM teachers should work closely with site and district ELD specialists to ensure that their classrooms serve EL students' English language development, in concert with an opportunity to learn science. By the same token, ELD specialists should work closely with science teachers to understand how to design and provide language instruction that is *in the service of* science and engineering learning (Pearson, Moje, and Greenleaf 2010). (See also the section in this chapter titled Integrated and Designated ELD and STEM.)

When designing integrated ELD science instruction, educators should carefully consider the level of their English learners and determine how the skills and concepts from the ELD Standards can support and provide access to the practice and mastery of grade-level science standards. Educators can provide opportunities for English learners to access rigorous science content by planning for targeted scaffolding in order to promote academic discourse and comprehension, analysis, and creation of written and spoken texts.

More detailed information about ELs can be found elsewhere in this framework, in the full CA ELD Standards publication, the *ELA/ELD Framework,* and the supplementary resource noted earlier in this section, *Integrating the CA ELD Standards into K–12 Mathematics and Science Teaching and Learning* (Lagunoff et al. 2015), which provides illustrative examples of the tandem implementation of the CA ELD Standards with the CA NGSS and CA CCSSM.

7. For newcomer ELs in secondary school (ELs who are within their first year in U.S. schools, for example), a specially designed science class that integrates ELD with science learning may offer an equally rich science learning experience.

Long-Term English Learners

Regardless of their age, primary language and literacy backgrounds, and time in U.S. schools, all ELs should make steady progress in developing English, particularly the types of academic English needed for school success. However, many ELs may not have received the educational support needed to make continual progress in developing the English that is essential to succeed in academic subjects. These students have been identified as *long-term English learners* (LTELs) because they have been schooled in the U.S. for six or more years but have not made sufficient linguistic and academic progress to meet reclassification criteria and exit EL status (see description of LTELs below). Fluent in social/conversational English but challenged by academic literacy tasks, LTELs find it difficult to engage meaningfully in increasingly rigorous coursework.

Long-Term English Learners

2013 California *Education Code* 313.1.a & b define a long-term English learner as "an English learner who is enrolled in any of grades 6 to 12, inclusive, has been enrolled in schools in the United States for more than six years, has remained at the same English language proficiency level for two or more consecutive years" as determined by the state's annual English language development test. In addition, the same California *Education Code* identifies English learners at risk of becoming long-term English learners as those EL students enrolled in any of grades five to eleven, in schools in the United States for four years, and who score at the intermediate level or below on the state's annual English language development test the fourth year at the below basic or far below basic level on the English language arts standards-based achievement test.

California recognizes that LTELs face considerable challenges succeeding in school as the amount and complexity of the academic texts they encounter increases. Special care should be taken when designing instruction for LTELs, as instruction should focus on accelerating the simultaneous development of academic English and content knowledge to ensure that LTELs are college- and career-ready. STEM coursework is an ideal discipline to support LTELs to achieve this accelerated trajectory because of its high-interest topics and focus on disciplinary literacy, not to mention its potential for group projects and real-world applications relevant to students' own lives (e.g., the relationships among science, technology, society, and the environment). Every effort should be made to enroll and retain LTELs in such course work and to provide the appropriate support and motivation to ensure their success.

Ethnically Diverse Learners

In 2009, only 12 percent of STEM workers had African American and Hispanic backgrounds even though these groups accounted for 25 percent of overall employment (Beede et al. 2011). African American, Hispanic, or Native American students earned less than 15 percent of undergraduate degrees in engineering, math, and physical science (National Science Foundation [NSF] 2013). This trend is worse for socioeconomically disadvantaged students (Shaw and Barbuti 2010). Multiple factors have been linked to the low numbers of underrepresented groups in STEM fields, including anxiety about perceived negative stereotypes and lower personal assessments of abilities and performance in STEM tasks (Hill, Corbett, and St. Rose 2010).

Overall, research suggests that the relationship between factors such as socio-economic status, ethnicity, academic self-efficacy, and academic performance is complex—and that reasons for the disparity of minorities in STEM fields are not universal. Factors affecting identity and persistence may operate differently, based on students' ethnic backgrounds, different performance levels in STEM, socio-economic backgrounds, and gender. Accordingly, the design of science and engineering curriculum and mentoring programs needs to align to students' prior and current degree of success in STEM learning and to factors such as socio-economic status and cultural backgrounds.

Migrant Students

Migrant students represent a significant number of California's children and adolescents. In 2014, California was home to nearly 200,000 migrant students, or about 35 percent of the country's total migrant-student population: about one-third of California's migrant students were classified as ELs (CDE 2014c). Schools and districts should be aware of the background factors that may affect the ways in which children and adolescents from migrant families engage in school learning. Most importantly, teachers should become familiar with their migrant students' circumstances so they can attend to their students' particular learning needs.

One of the greatest challenges migrant students face is access to and continuity of the services that are intended to meet their unique needs. The goal of California's migrant program is to provide supplemental services and supports to migrant students so they can be ready for and successful in school and graduate with a high school diploma that prepares them for responsible citizenship, further learning, and productive employment. When families move, migrant students' educational process is interrupted, and this can be exacerbated if the family moves to an area where there is not a migrant program or if the migrant program does not identify students and provide them with services in a timely way. Not only do the children and youth have an interruption in their education, but they also experience the interruption in services designed to help them overcome their unique challenges as migrant students.

Schools and districts are required to create and adhere to a systematic plan for identifying migrant students as soon as they enter their schools and for immediately providing appropriate services so that migrant students' education is not further disrupted. For more information and resources in meeting the needs of migrant students, see the CDE Migrant Education Programs and Services (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link3), the Migrant Students Foundation (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link4), and Colorín Colorado (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link5).

Students Living in Poverty

More than one in five California children and youth live in poverty (U.S. Census Bureau 2012). Some students are from families where parents are working one or more jobs, yet they are having difficulty surviving economically. Some students have moved often with their families, changing schools every year or multiple times each year because of economic circumstances, including job loss. Some are unaccompanied minors, others are living on the street or in shelters with their families, and still others have stable housing but may often go hungry or lack other basic necessities. They are a heterogeneous group made up of all ethnicities, but students of color are overrepresented in the population of students in kindergarten through grade twelve living below the poverty line (U.S. Department of Education 2013; see also Fuentes, O'Leary, and Barba 2013).

The challenges individuals living in poverty face are complex, and to mitigate the negative effects of poverty, the resources of many agencies working together are required. A broad interpretation of shared responsibility—one that includes agencies beyond the public education system—is crucial to serving these students effectively. However, schools can develop awareness of the challenges students living in poverty face and take tangible steps to support these students to succeed in STEM course work. Seeking expanded learning opportunities, for instance, may be one way to engage this student population in hands-on STEM learning that is relevant to their daily lives and promotes authentic learning and achievement.

Children and youth living in poverty are more likely than their peers to experience academic difficulty. However, the effects poverty has on individuals vary based on "the individual's characteristics (such as personality traits), specific life experience (such as loss of housing), and contextual factors (such as neighborhood crime)," as well as the presence of protective factors, which include affirming, positive, and supportive relationships with teachers and schools (Moore 2013, 4). Thus, the respectful, positive, and supportive schools called for throughout this chapter and this entire framework—important for all students—are especially critical for students living in the psychologically and physically stressful circumstances that come with poverty.

Children and youth living in poverty often miss many days of school; some stop attending altogether. Many transfer from one school to another as their living circumstances dictate. As a result, there are often gaps in their education. The CA NGSS is built on continuity of learning progressions across grade levels. This presents both opportunities and challenges to students who are highly mobile or transient. On one hand, the statewide implementation of the CA NGSS may help these students by providing them with consistent standards among districts and schools. On the other hand, this assumption may limit the ability of some students who are new to the school, district, state, or country (such as new immigrant or migrant students) to catch up, as they are unable to draw from a base of years of shared experiences. Likewise, students who miss school because of homelessness, migrant status, or other reasons involving mobility may struggle to fill gaps in understanding and skills development.

It is essential that teachers and districts identify student instructional needs early and work to determine how such needs may be addressed, as these issues cannot be addressed solely in the classroom. For instance, students living in poverty are more likely to struggle with engagement in school. Jensen (2013) discussed seven areas of concern for low-income students and recommended actions that teachers can take to mitigate their effects. Notably, children living in poverty who do experience academic success in the early years of school are more likely to succeed in subsequent years; early success in reading has been demonstrated to have particular significance for this population of students (Herbers et. al 2012). This encouraging finding suggests that a range of resources should be harnessed to more fully address the needs of these students. (See also Kaiser, Roberts, and McLeod 2011, 153–171, for a discussion of poverty and language delays.) See the *CA ELA/ELD Framework's* "Access and Equity" chapter for more specific strategies for working with students living in poverty.

When addressing the learning needs of children and youth living in poverty, it is important to recognize that students' backgrounds vary widely and that pervasive stereotypes and misconceptions about the poor can have damaging effects on students. Some misapprehensions include those that characterize the poor as unmotivated or as having a weak work ethic, those that assume that parents living in poverty do not value their children's education, those that view the poor as linguistically deficient, or those that stereotype the poor as drug abusers or criminals. Without actively questioning and addressing them, these myths and stereotypes can undermine the establishment of respectful learning environments where all students can thrive both academically and socio-emotionally. Gorski (2008) suggests that educators reject these myths and question the deficit stance from which they stem:

> The "culture of poverty" myth—the idea that poor people share more or less monolithic and predictable beliefs, values, and behaviors—distracts us from a dangerous culture that does exist—the culture of classism. . . . The most destructive tool of the culture of classism is deficit theory. In education, we often talk about the deficit perspective—defining students by their weaknesses rather than their strengths. Deficit theory takes this attitude a step further, suggesting that poor people are poor because of their own moral and intellectual deficiencies. (Collins 1988; Gorski 2008)

As Gorski emphasizes, myths that blame the poor for the inequities that exist in schools are not supported by evidence. Poor students are more likely than their more socioeconomically advantaged peers to attend schools that have

- less funding (Carey 2005);
- lower teacher salaries (Karoly 2001, 314–356);
- more limited computer and Internet access (Gorski 2003);
- larger class sizes;
- higher student-to-teacher ratios;
- a less-rigorous curriculum;
- fewer experienced teachers (Barton 2004);
- large numbers of teacher vacancies and substitute teachers;
- more teachers who are not licensed in their subject areas;
- insufficient or outdated classroom materials;
- inadequate or nonexistent learning facilities, such as science labs (The National Commission on Teaching and America's Future 2004; Gorski 2008).

Rather than approaching socioeconomically disadvantaged students and their families as having *deficits* that need to be *fixed,* this framework takes an asset-based stance, one that views all children and youth as coming to school with challenges that should be addressed but also as having valuable cultural and experiential resources that are useful for classroom learning. Furthermore, students living in poverty should be perceived as capable learners who are fully able to engage and achieve in intellectually rich STEM learning.

Foster Youth

More than 43,000—or about 1 of every 150 kindergarten through grade twelve public-school students in California—spent some period of time in foster care during the 2009–2010 school year (Wiegmann et al. 2014). Students in foster care, a group that is distinct from, but may overlap with, students living in poverty, lag significantly behind in academics compared to their peers who are not in foster care. Foster children and youth are more likely than other students to change schools during the school year and are more likely to be diagnosed with a disability than the general population of students (Wiegmann et al. 2014). In addition, students in foster care experience a greater academic achievement gap than students living in poverty and have the highest dropout rates and lowest graduation rates (Barrat and Berliner 2013).

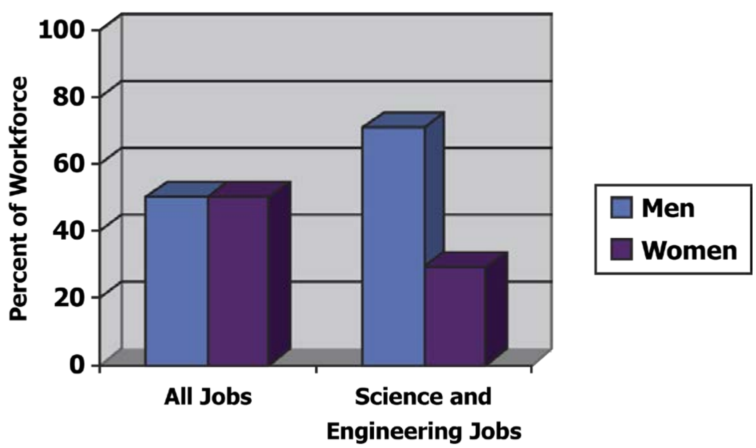
Despite the inequities that exist for foster youth, these students have the same aspirations for college and careers as other California students. "There is a shocking disparity between the number of foster youth who aspire to a college-level education and those who achieve this goal. In one survey of California foster youth, 75% had a goal of attending and graduating from college. However, an estimated 3–11% of foster youth actually go on to receive a bachelor's degree nationwide" (California College Pathways 2015).

The achievement gap that foster children and youth experience has been referred to as an *invisible* one. Educators may not be aware that their students are foster children or youth, and they may be unfamiliar with learning needs and appropriate support services that are particular to these students' life circumstances. However, when districts and teachers know who their foster children and youth are; place foster children strategically in the most appropriate schools and classrooms; and educate themselves about how to provide effective, motivating, engaging, and relevant instruction and support services, foster children and youth are more likely to thrive in school. Additionally, educators can refer students to participate in expanded learning opportunities, which provide collaborative, high-quality STEM learning, available at the school site. One example of support for school leaders is the College and Career Pathways project, which provides guidance to high schools on how to help foster youth plan for college and careers (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link6); another is the CDE, which provides numerous resources related to foster youth services and programs (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link7).

Girls and Young Women—Gender Equity in Science Education

Although women make up roughly half of the workforce in the United States, they hold less than 25 percent of the STEM jobs (see figure 10.1). This is particularly true in the physical, earth, engineering, and computer sciences. In addition, starting in the late 1990s, women have received around 57 percent of all undergraduate degrees, yet only 30 percent of women received undergraduate degrees in engineering (NSF 2013). These disparities, which are not due to a lack of ability or performance by women (Hazari, Tai, and Sadler 2007), are problematic for a number of reasons. First, the U.S. economy is losing the talent, innovation, and expertise of a large percentage of its total workforce. This loss prevents our nation's ability to "out-build, out-educate, and out-innovate future competitors" (Executive Office of the President 2013). In addition, the underrepresentation of women in STEM-related jobs places women at an economic disadvantage. Women in STEM jobs earn on average 33 percent more than their counterparts in non-STEM related jobs (Beede et al. 2011).

Figure 10.1. Gender Share of STEM Jobs



Source: K. Cruz Allen with data from National Girls Collaborative Project 2016
Long description of Figure 10.1.

Research points to a number of social and environmental factors that may impact young women's decisions not to seek STEM-related education and career trajectories. A strong influence impacting young women is the portrayal of gender stereotypes from the media and popular culture. From as early as age four, perceptions about the "appropriate" gender of scientists and engineers is influenced and reinforced by the media (Stienke et al. 2007). Predominant images of men in STEM-related fields in the media cause both girls/young women and boys/young men to see these fields as male dominated or more masculine in nature. This also impacts girls' and young women's self-image and beliefs about whether they can be successful in science and engineering. Another factor that may inhibit girls and young women from pursuing science and engineering is the inequality of participation in science classrooms. As Barton, Tan, and Rivet (2008, 68) note, "[T]raditionally, girls are positioned with less power in the science classroom. They are called on less often to answer content questions and are not given as much attention as the boys by the teachers." This can dramatically impact not only girls' interest and motivation to study science, but also their beliefs about whether they bring value to the science classroom.

Factors within and outside traditional classrooms can impact girls' STEM identities. To cultivate a positive science identity, girls must often navigate through dominant social perceptions of science as masculine and clever as well as the perception that STEM is an elite field open to a narrow range of women with very specific characteristics (Gomez-Zwiep 2015). This already limited arena is even smaller for girls from low SES backgrounds or who are from underrepresented ethnic groups (Carlone 2012). Often, inspiration for STEM-related goals is the result of out-of-school opportunities where girls experience science in a way that makes them feel smart and capable. Such experiences can come from expanded learning opportunities in which girls can engage in relevant, hands-on STEM learning—and can be pivotal for promoting efficacy and confidence in STEM-related content. Other reaffirming practices could include school-based grades, providing certificates and awards, and teachers promoting positive STEM identities to girls (Tan et al. 2013).

Making girls aware of women in STEM careers is not enough to develop a positive STEM identity in girls. Explicitly discussing the under-representation of women in STEM fields and other similar practices has been shown to have a positive effect on girls STEM-identity formation (Archer et al. 2012). Exposing female students to female role models can also strengthen girls' STEM identity—but only when the students develop a significant personal connection with those role models. These findings highlight the important role of STEM-focused expanded learning opportunities where girls can collaborate and build longitudinal relationships with female role models on a regular basis by engaging in hands-on, minds-on STEM learning opportunities relevant to their needs and interests.

Many of California's teachers, schools, and districts have already embraced several research-based approaches to positively impact girls' motivation, achievement, and confidence with science and engineering. One approach is to ensure that girls clearly see science and engineering as useful to society and meaningful pursuits by including engineering experiences and discussions of applications of science and of science-based technologies into school programs. Increasing girls' self-efficacy in science and engineering can be accomplished by providing early school experiences with science, such as science projects and scientific investigations, which can be critical in developing life-long interests in science and their pursuit of careers in science (Baker 2013).

Not only should students be exposed to science and engineering at a young age, but they should also have meaningful access to successful women who work in science- and engineering-related fields. This exposure serves to break down the gender stereotypes that students form from the media and popular culture. Baker also found that "the most effective role models for girls are women near their own age, such as female undergraduate science majors or graduate students who can talk about their experiences in nontraditional fields" (Baker 2013, 16). Women science teachers can also serve as strong and positive role models for girls and young women in their classrooms. Expanded learning opportunities typically include partnerships with local institutions of higher education or community organizations that provide such mentors to female students on an ongoing basis.

All teachers and education support professionals should ensure they create learning environments that promote open dialogue, risk-taking, and a culture that values learning where all students feel safe and excited about engaging with science and engineering. All teachers can support girls and young women to thrive in the science and engineering classroom by engaging in the following actions:

- Intentionally positioning girls and young women in leadership positions during group work (Barton, Tan, and Rivet 2008)
- Conveying positive messages about the competencies of girls and young women (Baker 2013)
- Intentionally highlighting and/or providing access for all K–12 students to women role models and/or mentors in science and engineering fields
- Critically and continuously self-assessing how they ensure that their female students have equal opportunities to participate in tasks and classroom discourse
- Collaborating with parents and guardians and explicitly informing them of the career opportunities in STEM-related fields for women so they can support their daughters' developing identities as scientists and engineers

These approaches and others will help to ensure gender equity in science classrooms and in STEM-related careers. The following snapshot illustrates how a school program can support girls and young women to develop a growth mindset, the idea that people can grow their brain's capacity to learn and to solve problems, in relation to STEM.

Access & Equity Snapshot 10.1: SciGirls in Grades Four and Five

An after-school group called SciGirls (inspired by the local television show by the same name) recruited girls in grades four and five to cultivate a school garden and explore ecological relationships through STEAM. The group of 25 girls who regularly attended meetings focused on one performance expectation per year. They had planted and maintained a school garden, started a small compost pile, and worked as advocates around the school to do mini-presentations for the kindergarten through fifth-grade students about plants and human impacts on the environment (5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment).

During a storm, some of the girls noticed that worms were littering the sidewalk. Miss C, the club's advisor, took advantage of this experience to arrange for an education outreach staff person from the local waste company to discuss vermicomposting and the anatomy and physiology of the worm. The girls then created a *worm box* and used this box to conduct various investigations, such as comparing plant growth with and without using worm castings, observing the average size of individual worms given various diets, and observing the number of living worms given varying amounts of food. There was also an emphasis on reading science informational texts, collecting and analyzing data, and writing for the school Writing Celebration. The girls were provided extra support when working on their science fair projects and used observations and scale drawings to submit entries to the art fair.

The SciGirls group was continued in the middle grades, where the focus was on engineering. In grade eight, the girls worked with the grades four and five program at the elementary school as mentors.

For more information and for resources on empowering girls and young women in science and engineering, see the following reports by the American Association of University Women:

- *Why So Few? Women in Science, Technology, Engineering, and Mathematics (STEM)* presents eight key research findings that point to environmental and social barriers that block women's progress in STEM along with ideas for opening up science and engineering fields to girls and women (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link8).
- *Where the Girls Are: The Facts About Gender Equity in Education* presents a comprehensive picture of trends in gender equity from elementary school to college and beyond (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link9).
- "Solving the Equation: The Variables for Women's Success in Engineering and Computing," a report by the AAUW (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link10)

Advanced Learners and Gifted Learners

Advanced learners and gifted learners, for purposes of this framework, are students who demonstrate or are capable of demonstrating performance in science and engineering at a level significantly above the performance of their age group. They may include (1) students formally identified by a school district as gifted and talented pursuant to California *Education Code* Section 52200 and (2) other students who have not been formally identified as gifted and talented but who demonstrate the capacity for advanced performance in particular subject areas. In California, each school district sets its own criteria for identifying gifted and talented students.

The informal identification of students' learning needs (as noted in number 2 above) is important because some students, particularly California's culturally and linguistically diverse learners, may not exhibit advanced learning characteristics in culturally or linguistically congruent or familiar ways. For example, a kindergartener who enters U.S. schools as a newcomer to English and is fluently translating for others by the end of the year may not be formally identified as advanced but may in fact be best served by programs offered to gifted and talented students. Likewise, teachers may not readily identify students with disabilities as gifted and talented, yet some students with disabilities are gifted and talented. These students are sometimes referred to as *twice exceptional* and instruction needs to address both sets of needs (International Dyslexia Association 2013; Nicpon et al. 2011). Teachers should be prepared through pre-service and in-service professional learning programs to recognize the range of learners who are gifted and talented. As noted previously, the populations discussed in this chapter are not mutually exclusive, and each is heterogeneous.

A synthesis of research (Rogers 2007) on the education of students identified as gifted and talented suggests that they should be provided the following:

- Daily challenges in their specific areas of talent
- Regular opportunities to be unique and to work independently in their areas of passion and talent
- Various forms of subject-based and grade-based acceleration as their educational needs require
- Opportunities to socialize and learn with peers with similar abilities
- Instruction that is differentiated in pace, amount of review and practice, and organization of content presentation

Instruction for advanced learners and gifted learners should focus on adding depth and complexity in their understanding of the topics being studied, and not necessarily in adding new topic areas or skipping courses or content. For example, opportunities to engage with appropriately challenging text and content, conduct research, engage in independent or small-group projects, use technology creatively, and write regularly on topics that interest them can be especially valuable for advanced learners and gifted learners; these experiences allow students to engage more deeply with content and may contribute to motivation. Instruction that focuses on depth and complexity ensures cohesion in learning rather than piecemeal enrichment.

Assessments and tasks vary in their cognitive complexity, or *depth of knowledge* (DOK), they require (Webb 2005). Depth of knowledge levels include, from least to most complex, the following:

- Recall and reproduction (level 1)
- Skills and concepts (level 2)
- Strategic thinking/reasoning (level 3)
- Extended thinking (level 4)

The more complex tasks, those at DOK levels 3 and 4, generally require more time and involve the use of more resources. An overview of DOK with science examples is presented in this framework in chapter 11 on instructional strategies. All students should have ample opportunities to engage in a mixture of tasks with particular attention to those most cognitively engaging and challenging, that is, tasks involving strategic thinking/reasoning and extended thinking. Advanced learners and gifted learners particularly benefit from opportunities and encouragement to carry their projects and tasks through to these more complex DOK levels.

Students with Disabilities

In accordance with The Individuals with Disabilities Education Improvement Act (IDEA), reauthorized in 2004, California local education agencies provide special education and other related services as a part of a guaranteed free appropriate public education to students who meet the criteria under one of the following categories (presented alphabetically): autism, deafness, deaf-blindness, emotional disturbance, hearing impairment, intellectual disability, multiple disabilities, orthopedic impairment, other health impairment, specific learning disability, speech or language impairment, traumatic brain injury, and visual impairment, including blindness. (For detailed descriptions, see the Center for Parent Information and Resources, https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link11.)

Students with specific learning disabilities and speech and language impairment make up approximately two-thirds of students receiving special education services (CDE 2011). While specific learning disabilities vary widely, difficulty reading is the most common type of specific learning disability. However, it is important to note that students experiencing difficulty reading do not necessarily have a learning disability. There are many causes for low achievement in reading, including inadequate instruction. Under IDEA, a student who is performing below grade level may not be determined to have a specific learning disability if the student's performance is primarily a result of limited English proficiency or a lack of appropriate instruction. A student's membership in a particular disability category only represents a label for a qualifying condition. The spectrum of severity of disability and educational needs within each disability category varies widely. Thus, each individual education program should be based on a student's individual needs—not the label attached to the student.

Individualized Education Program

Students who receive special education and related services in the public school system must have an Individualized Education Program (IEP). For more information, see *What is an IEP?* from Understood (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link12). The IEP is a federally mandated individualized document specifically designed to address an individual's unique educational needs. It includes information about the student's present levels of performance (including strengths), annual goals, and the services and supports that are to be provided in order to meet those goals. The members of the IEP team—students, teachers, parents, school administrators, and related services personnel—work collaboratively to improve educational results for students with disabilities. IEPs for ELs with disabilities should include linguistically appropriate goals and objectives in addition to all the supports and services the student may require due to their disability. The IEP serves as the foundation for ensuring a quality education for each student with a disability.

For additional resources to support the teaching of students with disabilities, please access VeryWell.com https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link13 to learn more about 504 plans and suggested accommodations. A 504 plan refers to Section 504 of the Rehabilitation Act and the Americans with Disabilities Act (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link14), which specifies that no one with a disability may be excluded from participating in federally funded programs or activities, including elementary, secondary, or postsecondary schooling.

Accommodations and Modifications for Students with Disabilities

Most students who are eligible for special education services are able to achieve standards when the three following conditions are met:

1. Standards are implemented within the foundational principles of Universal Design for Learning. (See subsequent section in this chapter.)

2. Evidence-based instructional strategies are implemented and instructional materials and curriculum reflect the interests, preferences, and readiness of each student to maximize learning potential.
3. Appropriate accommodations are provided to help students access grade-level content and complete tasks successfully.

Accommodations are changes that help a student to overcome or work around the disability. Accommodations do not reduce the learning or performance expectations; rather, they allow the student to complete an assignment or assessment with a change in *presentation, response, setting, timing* or *scheduling* so that learners are provided equitable access during instruction and assessment. They also include learner-appropriate behavior management techniques.

More guidance is available in the CCSSO's *Accommodations Manual: How to Select, Administer, and Evaluate Use of Accommodations for Instruction and Assessment of Students with Disabilities* (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link15) (Thompson et al. 2005).

The following snapshot provides an example of several accommodations in practice and highlights the need for science and special education teachers to collaborate toward the common goal of ensuring that students with special needs have full and equitable access to a robust science and engineering curriculum.

Access & Equity Snapshot 10.2: Science and Special Education Teachers Co-planning: Applying Newton's Third Law

There were 8 students with mild to moderate learning disabilities out of a total 32 students in Mrs. C's sixth-period physical science class. Mrs. C regularly met with Ms. S, a special education specialist and the primary case holder for the students in Mrs. C's class, to plan accommodations for her lessons that period. In science, the students had been studying Newton's Laws, and with instructional support had been successful at conceptually understanding the content.

Mrs. C's physical science classes were designing a wall made of Jenga blocks that would stop a tennis ball with a constant force (caused by rolling it down a ramp). During co-planning time, she explained the activity and her expectations for student work to Ms. S. She was planning for students to begin by making qualitative and quantitative observations about the system (e.g., dimensions and mass of the ball and block, and the distance of travel before collision point), followed by calculating the average speed

Access & Equity Snapshot 10.2: Science and Special Education Teachers Co-planning: Applying Newton's Third Law

the ball was traveling at the proposed collision point (by collecting distance and time data in a table for multiple trials). Next, students investigated building a wall with 1–10 blocks, noting how far the ball traveled after collision with multiple designs. The students recorded trials in their science notebooks with labeled diagrams, which included noting the forces acting upon the system using arrows of varying lengths. Finally, students made a prediction about how many blocks it would take to stop the ball, created a labeled design, and wrote a short claim for why they believed that this design would stop the ball. In their writing, the students had to use the terms *force, mass, speed, motion, collision,* and *Newton's laws*.

After listening to each activity and expectation, Ms. S offered suggestions for modifications and accommodations at each stage of the lesson. She began by proposing an extension to the allocated time for the entire activity from 1–2 days to 2–3 days, chunking the investigations into smaller steps. She suggested that the whole class make the observations and that the students collect the data during science. She asked if she could support the cluster of students with special needs when she saw these students during math by giving them extra time to work on the calculations. In addition, she believed the students might be more successful with the wall-building portion if time limits were given for building and then drawing their diagrams, thereby providing time management for the task. Finally, for the short claim writing assignment, she suggested that the students with special needs be provided with a glossary of the required terms. She also suggested that the students compose the claim in pairs or triads, rather than alone, so that they could first talk with others about how they would phrase their claims in writing.

Mrs. C noted the modifications in her lesson plan, and the two teachers next decided how Mrs. C would observe this group of students during instruction so that she could provide immediate support. The following week, when the two teachers met again for co-planning, they reflected on how the students engaged in the tasks so that they could continue to provide supports that were most useful and consider others that may be more appropriate for individual students.

Access & Equity Snapshot 10.2: Science and Special Education Teachers Co-planning: Applying Newton's Third Law

MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
[SEP-6] Constructing Explanations and Designing Solutions (for engineering) Constructing explanations and designing solutions in grades 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	PS2.A: Forces and Motion For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's Third Law). PS3.C: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	[CCC-4] Systems and System Models Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.

Unlike accommodations, *modifications* are adjustments to an assignment or assessment that changes what is expected or measured. Modifications should be used with caution as they alter, change, lower, or reduce learning expectations and can increase the gap between the achievement of students with disabilities and expectations for proficiency. Examples of modifications include the following:

- Reducing the expectations of an assignment or assessment (e.g. assigning fewer questions, less material, and/or lower-level problems)
- Making assignments or assessment items easier
- Providing clues to correct responses

Accommodations and modifications play important roles in helping students with disabilities access the core curriculum and demonstrate what they know and can do. The student's IEP or 504 Plan team determines the appropriate accommodations and modifications for both instruction and state and district assessments. Decisions about accommodations and modifications are made on an individual student basis, not on the basis of category of disability. For example, rather than selecting accommodations and modifications from a generic checklist, IEP and 504 Plan team members (including families and the student) need to carefully consider and evaluate the effectiveness of accommodations for each student.

Accommodations and modifications support equitable instruction and assessment for students with disabilities. Accommodations and modifications should be cohesive across classroom instruction, classroom tests and state/district assessments. However, some accommodations and modifications may be appropriate only for instructional use and may not be appropriate for use on a standardized assessment. It is crucial that educators are familiar with state policies regarding accommodations used during assessment.

In a classroom where students engage in science and engineering practices (SEPs), additional accommodations may be needed for some students to participate fully in the activity and discourse expected of the class. Classroom access to laboratory equipment may be limited by reach or vision. When this occurs and cannot be easily remediated, strategies to ensure inclusion of the student with disabilities must, for example, ensure that the student is positioned to gain the best possible visual, auditory, and physical access to instruction and materials, and that they are included as fully as is possible as a member of the group in any project and laboratory work.

Disciplinary Literacy, Motivation, and Self-Efficacy

The CA NGSS promotes SEPs and pedagogy that are equity-focused. In particular, student discussion and disciplinary literacy play a much larger role than with previous standards. This presents a challenge for teachers to fully include all students in classroom discourse and to address science literacy. It also provides an opportunity for all students to engage in discussion and literacy tasks in the context of rich science and engineering learning environments. Engaging in rich discussions about science and engineering supports all students to develop the *language of science and engineering* and to extend their conceptual and content understandings. Therefore, science and engineering teachers in formal, informal, and expanded-learning environments should develop their abilities to facilitate and manage such discussion-based learning in order to ensure that all students are included in discussions and to make the most of the language and content learning opportunities. (For more about how the CA NGSS promotes classroom discourse about science and engineering, see chapter 1 in this framework for an explanation of three-dimensional science learning.)

Science and engineering instruction should support continued language and literacy development, with an emphasis on disciplinary literacy and development of mathematical thinking, in addition to science learning. This integration of language and literacy, science, and mathematics supports, rather than diminishes, student achievement in each of these disciplines. (For more information on disciplinary literacy and the role of discussion in science and engineering, see chapter 11 on instructional strategies in this framework.)

In addition to an increased focus on discourse and disciplinary literacy, the CA NGSS provide opportunities for teachers to promote in their students an interest and sense of self-efficacy in STEM, as well as a way of seeing themselves as scientists and engineers. Student interest in STEM is a primary goal of STEM education, whether that interest leads to the ability to apply a general knowledge of STEM to daily decisions in one's personal life or a career in a STEM field. Interest in STEM can facilitate learning and is related to other important learning factors such as self-efficacy, goal setting and self-regulation. The development of interest can be cultivated and supported through positive personal interactions (e.g., teacher-student, student-student) and the strategic design of the learning environment (Renninger and Hidi 2011). In the middle grades, external factors begin to influence the academic pathway students will take (Lanzilotti, Montinaro, and Ardito 2009, 63–72), and student interest in STEM-related subjects is closely related to their likelihood of pursuing a STEM career in the future (Tai et al. 2006; Fouad, Smith, and Zao 2002). Student attitudes are influenced by how topics are presented in instruction, such as inquiry-based practices (Minner, Levy, and Century 2010) and by the topics of instruction, such as projects related to issues of power, culture, and ideology (Zacharia and Barton 2004). When science is taught through engaging, hands-on experiences, it often becomes the most interesting domain for students, leading to increased interest (Jones, Howe, and Rua 2000). Activities involving experiments and lab or project work increase student engagement and promote student interest in STEM disciplines and careers when compared to purely cognitive work such as reading or listening to lectures. (For additional information see chapter 11 in this framework).

Some of the most promising research related to increasing STEM participation has been conducted by Dweck (2006) in the area of mindset. This research identified a *growth mindset* in which individuals perceive intelligence as a changeable and flexible characteristic that could be developed with effort and persistence. Individuals with a growth mindset are likely to persist in the face of struggle and adversity. Other individuals, those with a *fixed mindset,* believe that intelligence is determined at birth and is uncontrollable. Unfortunately, individuals with a fixed mindset are more likely to lose confidence in the face of struggle. Students who possess a fixed mindset may have difficulty persisting after setbacks in math and science, believing that the need to *work hard* is an indication that they are inherently not smart enough for the task. While gender gaps have been found in boys and girls with fixed mindsets, it is encouraging that no gender difference exists among students of growth mindsets (Grant and Dweck 2003; Dweck 2006). Girls who believe that they can develop the skills and knowledge needed to be successful in STEM fields are more likely to resist stereotypes and develop positive STEM identities (Good, Aronson, and Harder 2008).

Universal Design for Learning

Universal Design for Learning (UDL) is a research-based framework for guiding educational practice (see https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link16). Based on the premise that one-size-fits-all curricula create unintentional barriers to learning for many students, including the mythical average student, UDL focuses on planning instruction to meet the varied needs of students. Not a special education initiative, UDL acknowledges the needs of all learners at the point of *first teaching,* thereby reducing the amount of follow-up and alternative instruction necessary.

UDL involves the use of effective teaching practices and the intentional differentiation of instruction from the outset to meet the needs of the full continuum of learners. Teachers who employ UDL attend to how information is shared along with choices of action, expression, and engagement. In other words, as they plan, general education teachers consider different ways to present information and content, different ways the students can express what they know, and different ways of stimulating students' interest and motivation for learning—all based on students' needs (CAST 2011).

The UDL guidelines are organized by three primary principles. A table representing these principles and guidelines, as well as practical suggestions for classroom implementation can be found at the National Center for UDL at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link17. An example of UDL in action is provided in the following snapshot: Universal Design for Learning in a High School Biology Class.

Access and Equity Snapshot 10.3: Universal Design for Learning in a High School Biology Class

Ms. H's biology class was learning about the role of feedback mechanisms in stabilizing or destabilizing a system. As an introduction to the concept, Ms. H activated prior knowledge (guideline 1) and facilitated a brief conversation about a feedback mechanism with which the students had some familiarity: the air conditioner. To support students' conceptual understanding, Ms. H previewed key terms by providing the students with a document that clarified domain-specific vocabulary with definitions and illustrations (guideline 2). For example, the document defined the word *receptor* and had an illustration of a thermometer so students made the connection between the feedback mechanism component and the system being discussed.

In groups, students created a two-dimensional model of the feedback mechanism using words and illustrations. During the creation of these models, Ms. H asked guiding questions about systems and system models to ensure students included all necessary components. Individual group models were used to create a class model that Ms. H used to check for understanding of the feedback mechanism. Instead of eliciting a choral response from students, students answered questions using a clicker or their phone, which provided Ms. H with both group and individual data (guideline 4).

Later in the lesson, the students examined specific feedback mechanisms in their own bodies. Students were shown a five-minute video clip explaining the feedback mechanism involved in maintaining blood glucose levels. Ms. H told the students to watch the video with the purpose of identifying the components of the feedback mechanism. During this video, students were not to take notes. After the video, students were given a transcript (guideline 1) and time to read through it, then instructed to use text-marking strategies to identify the components of the feedback mechanism. Students then watched the video a second time, taking notes that would allow them to create their own model of the feedback mechanism.

Ms. H knew that some of her students would struggle with creating a model of the feedback mechanism for maintaining blood glucose levels, so she provided these students with a template as scaffolding (guideline 5). Students were given many options for demonstrating their understanding of the feedback mechanism and how the system responds to a given stimulus (guideline 5). These options were presented to the students in the form of a menu with different activities and assignments having differing point values. Students selected which of the activities they wanted to use to demonstrate their understanding, as long as the points added up accordingly. This could take place in the form of an essay, PowerPoint, Prezi, comic strip, or other activity.

When initial instruction is planned in such a way that it flexibly addresses learner variability, more students are likely to succeed. Fewer students will find the initial instruction inaccessible and, therefore, fewer will require additional, alternative "catch-up" instruction.

Multi-Tiered System of Supports

A coordinated system of supports and services is crucial for ensuring appropriate and timely attention to students' needs. STEM teachers need to be part of this system as it is a shared responsibility to collaborate with teachers, specialists, school administrators, and other stakeholders to provide the most appropriate support for all students. The Multi-Tiered System of Supports (MTSS) model expands California's Response to Intervention and Instruction (RtI^2) process by aligning all systems of high-quality first instruction, support, and intervention and including structures for building, changing, and sustaining systems. The MTSS guidelines discussed below reflect a schoolwide approach; these include considerations specific to science instruction.

The foundational structures of MTSS include high-quality core instruction using UDL principles and appropriate supports, strategies, and accommodations. In addition, assessments and progress monitoring are employed to allow for a data-based, problem-solving approach to instructional decision-making. Like RtI^2, MTSS incorporates the three-tiered structure of increasing levels of supports and begins with the establishment of strong core instruction in Tier 1. These tiers reflect the intensity of instruction in all content areas, not specific programs, students, or staff (i.e., Title 1 or special education).

- **Tier 1:** Tier 1 core or universal instruction, also known as *first teaching,* is differentiated instruction delivered to all students in general education. Differentiated instruction is the use of a variety of evidence-based instructional approaches to transform curriculum and instruction in response to the interests, preferences, learning needs, and readiness of diverse learners. It is not a program, but a way for teachers to think effectively about whom they teach, where they teach, and how they teach to maximize all students' academic potential (Glass 2012). Teachers design instruction for this tier in accordance with the principles of UDL (see previous section in this chapter). The goal is that all students receive high-quality NGSS-aligned STEM instruction through culturally and linguistically responsive teaching (see next section in this chapter) and other equity-focused approaches that meet the full range of student needs. Tier 1 instruction should result in no less than 80 percent of students achieving grade-level expectations. If less than 80 percent of students succeed in Tier 1 instruction, schools should engage in close examination of the curriculum and teaching practices and make appropriate adjustments.
- **Tier 2:** Tier 2 is strategic, targeted instruction and supports provided to *some students*—those who are not progressing or responding as expected to appropriately designed and expertly provided first teaching (Tier 1). When Tier 1 instruction is

excellent, no more than 15 percent of students receive support at this level. Tier 2 instructional supports are provided to students *in addition* to the high-quality instruction they receive in Tier 1. The supplemental instruction provided in Tier 2 may be an extension of the core curriculum used in Tier 1, or it may include instructional materials and activities specifically designed for intervention. Tier 2 instruction may take a variety of forms. At the elementary level, Tier 2 support might entail targeted instruction provided for 30 minutes each day to small, flexible groups for six to eight weeks. It may include support to ensure that students have understood and can apply the scientific content knowledge and skills they need to be successful in STEM classes. At the secondary level, Tier 2 support might include temporary support (before, during, or after school) during which concepts taught in the core curriculum are previewed or reviewed; the concepts may include STEM learning. Students' progress toward identified goals is monitored frequently. The goal is that supplemental support is temporary and that students will make significant and accelerated growth to succeed in Tier 1 instruction. It is critical to note that students should not be removed from science and engineering instruction in order to receive Tier 2 support.

- **Tier 3:** Tier 3 consists of intensive intervention. It is necessary for very few students: 5 percent or less. Students who receive these services are those who have experienced difficulty with excellent Tier 1 first instruction and have not benefitted as expected from the appropriately designed and provided Tier 2 supplemental instruction they received. More intensive, Tier 3 intervention may occur in a learning center or may be at a different pace than Tier 2 instruction. The instruction for elementary students in Tier 3 might be for 40–60 minutes daily for a period of six to eight weeks, although some students may need intensive intervention for longer periods of time. This additional support may include opportunities for students to more fully understand and apply the scientific knowledge and skills they need to be successful in STEM classes. Tier 3 intervention for secondary students might consist of a double block of daily instruction for a semester or longer. In both elementary and secondary settings, the instructional goal is to provide research-based intervention more often and for longer periods of time with reduced student/teacher ratios. The intention is to accelerate students' progress so they can return to and succeed in the core Tier 1 instructional program. STEM teachers' understanding of how to collaborate with specialists to design and implement appropriately differentiated instruction and interventions is critical for ensuring that individual students succeed in their STEM courses. Equally important for all educators is to ensure that students receiving either Tier 2 or Tier 3 supports not be deprived from participating in engaging STEM coursework, as full participation in this coursework is critical for ongoing content knowledge, language, and literacy development.

For additional information, access the California Department of Education's Multi-Tiered System of Supports Web page at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link18.

Culturally and Linguistically Responsive Teaching

Culturally and linguistically responsive teaching and equity-focused approaches emphasize validating and valuing students' cultural and linguistic heritage across the curriculum, as emphasized in the following discussion.

Culturally and Linguistically Responsive Teaching

Culturally and linguistically responsive teaching can be defined as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them. It teaches to and through the strengths of these students. It is culturally validating and affirming. Along with improving academic achievement, these approaches to teaching are committed to helping students of color maintain identity and connections with their ethnic groups and communities. It helps develop a sense of personal efficacy, building positive relationships and shared responsibility while they acquire an ethic of success that is compatible with cultural pride. Infusing the history and culture of the students into the curriculum is important for students to maintain personal perceptions of competence and positive school socialization.

Source: LAUSD English Learner (EL) Master Plan 2012.

Science education is a unique arena for integrating pedagogy that is responsive to the diversity and life experiences of California's students. Culturally and linguistically responsive teaching weaves together multiple goals related to social justice. The National Center for Culturally Responsive Educational Systems (NCCRESt) highlights the importance of creating a shared responsibility for cultural responsiveness:

> Culturally responsive educational systems are grounded in the belief that we live in a society where specific groups of people are afforded privileges that are not accessible to other groups. By privileging some over others, a class structure is created in which the advantaged have more access to high-quality education and later, more job opportunities in high-status careers. This leads to socioeconomic stratification and the development of majority/minority polarity. We can turn the tide on this institutionalized situation by building systems that are responsive to cultural difference and seek to include rather than exclude difference. … Moreover, culturally responsive educational systems create spaces for teacher reflection, inquiry, and mutual support around issues of cultural differences. (National Center for Culturally Responsive Educational Systems 2008, 15)

To ensure that all students thrive in STEM fields, teachers should adopt an *additive* stance toward the culture and language of their students by enacting the following principles:

1 Promote and model a positive disposition toward diversity: Teachers should develop an awareness of and positive disposition toward their students' cultural and linguistic heritage and communication styles. Teachers should also clearly exhibit a positive disposition about the science-related cultural frameworks and experiences students from diverse backgrounds bring to the classroom and generally promote positive dispositions toward diversity among all students (LeMoine 1999; McIntyre and Turner 2013, 137–161; Moll et al. 1992).

2 Recognize and leverage cultural and experiential backgrounds: Teachers should learn about their students' lives, seek out the science-related cultural and experiential knowledge and interests their students bring to school, and make connections to new STEM learning. This includes instructional actions such as using texts that feature scientists from a variety of cultural and linguistic backgrounds, inviting students to share their experiential and cultural knowledge in science and engineering lessons, and addressing issues of social injustices related to science that have affected people of color, immigrants, and the poor (McIntyre and Turner 2013, 137–161).

3 Value language diversity and address language status: Teachers should convey the message that all languages and dialects of English are equally valid and useful in classroom learning and take the stance that multilingualism and dialect variation is natural. While students should be encouraged and supported to use the language of science, the language they use during discussions, group projects, and other group work (such as lab experiments) should be accepted, with the focus on learning science, rather than on whether students use their home dialects or primary languages to communicate their ideas. In addition, teachers should make transparent for their students, in developmentally appropriate ways, that while standard English is the type of English privileged in school and is necessary to learn for expanded opportunities in life, bilingualism and bidialecticism (proficiency in multiple dialects of English) are highly valued assets (Harris-Wright 1999, 53–80).

4 Cultivate the development of academic English: Teachers should draw students' attention to academic uses of English in STEM. They should integrate intellectually rich and engaging tasks that allow students to develop their ability to use academic English in meaningful and authentic ways. Teachers should also make transparent to students how academic English works to make meaning in particular ways in science (disciplinary literacy). This includes helping students to develop *register awareness* so that they understand how and when to use different types of English to meet the language expectations of STEM fields (Schleppegrell 2004; Spycher 2013, 445–458). (To learn more about register and register awareness, see figure 2.14 in the *ELA/ELD Framework*.)

All students bring to school knowledge and experiences that have the potential to promote science learning. The cultural and linguistic knowledge and experiences that some children bring to school may not initially be seen as assets, but they can be. For example, the family or community of some students in rural regions may have deep and specialized knowledge of organic farming practices or herbal medicines. In urban settings, some children may have experiences learning technical procedures, such as bicycle repair or building a community garden with their families. These types of informal science experiences and knowledge can be drawn upon to enhance what is happening in the classroom, for example, during science units involving plant biology, ecology, physics, or chemistry. When teachers are aware of their students' *funds of knowledge,* they can create *zones of possibilities,* in which academic learning is enhanced by the bridging of the science curriculum with family and community ways of knowing (Moll and Gonzalez 1994). However, teachers should not make assumptions about the types of knowledge a student brings based on their ethnicity, but rather encourage and elicit that knowledge based on insights offered by the student and conversations with families. Teachers should also be willing to explore students' perceptions of how science and technology has on occasion ill-served their community and to include discussions of risk and disadvantages as well as of opportunity and advantages offered by science and technology for society. Some brief examples of culturally and linguistically responsive pedagogy include the following snapshots. For additional examples, see the NGSS appendix D: Diversity and Equity case studies at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link19.

Access and Equity Snapshot 10.4: Learning About Bioethics in High School

The science, history, literature, and ELD teachers at Bay View High School collaborated to design and teach an interdisciplinary unit using Rebecca Skloot's book *The Immortal Life of Henrietta Lacks* as a springboard for multiple, interrelated topics. In biology class, students learned about Henrietta Lacks and how the HeLa genome had been vital to the development of the polio vaccine, cloning, gene mapping, in vitro fertilization, and other advancements. Students then read informational science texts on these topics. They also learned about the dark history of experimentation on African Americans and traced the history of bioethics.

In history class, the students discussed relationships between ethics, race, and medicine as they explored questions based on Skloot's book and primary source documents (e.g., Did the fact that she was black and poor affect her level of care?

Access and Equity Snapshot 10.4: Learning About Bioethics in High School

What laws governed the use of cells harvested from unknowing donors in the 1950s?). In literature, the students read and discussed sections of the various texts to deeply understand the content and learn about the structure and rhetorical features of nonfiction.

As a culminating task, the students worked collaboratively in small research groups to investigate current events focused on bioethics, about which they then wrote creative nonfiction pieces and created media presentations, which could be posted on the school's Web site. In their designated ELD class, the EL students delved more deeply into the language used in Skloot's book and some of the informational texts used in their science class, analyzing and discussing the text organization, the structure of the texts, and the lexical and grammatical resources the authors use. As the unit progressed, the teachers met regularly to discuss both student progress and student work and to make necessary enhancements and adjustments to the unit.

Resources

Rebecca Skloot's Web site (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link20).

Radiolab's program: Henrietta's Tumor (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link21)

Access and Equity Snapshot 10.5: Learning from STEM Role Models in the Middle Grades

The teachers at STEM Academy Middle School worked together to ensure that their students learned about role models in STEM fields. The teachers selected role models who reflected the cultural diversity of the school and who also had great potential to inspire their students to persevere in STEM course work and pursue careers in STEM fields. One of the role models students learned about was teen scientist Jack Andraka, a 15-year-old high school sophomore, who invented an inexpensive early detection test for pancreatic, ovarian, and lung cancers and has won numerous awards. In addition to learning about Andraka's scientific contributions, they also learned how the young inventor had earned international praise for sharing his personal and motivational story—in multiple documentaries, journal articles, and a memoir—depicting his experiences of bullying, depression, rejection, and ultimately international success.

One of the texts students read and discussed was an op-ed Andraka wrote for *The Advocate* entitled "How Gay Genius Alan Turing Got Me Through Middle School" (Andraka 2014). In the piece, Andraka explained how inspiring and motivational it was for him in middle school to discover a role model who was also gay: Alan Turing, who thwarted

Access and Equity Snapshot 10.5: Learning from STEM Role Models in the Middle Grades

Nazi Germany in World War II by cracking the Enigma code and laid the groundwork for modern-day computers. However, because Turing lived in a time when being gay was a criminal offense, he was persecuted by authorities and committed suicide at the age of 41. Andraka lamented the paucity of role models in STEM fields for lesbian, gay, bisexual, and transgendered youth and advocated for changes in STEM education, adding, “The sacrifice of our intellectual diversity is one that is not necessary and simply not acceptable. If we truly desire equality in our society, then we must break free from our stereotypes, making our foremost feature not our sexuality, but our potential to improve the world” (Andraka 2014). As the students learned about Andraka, they discussed his contributions to science and how he serves as a role model for other teens. Small groups selected one of the “do-it-yourself” science experiments included in each chapter of Andraka’s memoir (which he had created), and they worked together to conduct them.

Another group of role models the students learned about is depicted in Joshua Davis’s book *Spare Parts: Four Undocumented Teenagers, One Ugly Robot, and the Battle for the American Dream.* The informational text told the story of a robotics team comprised of four Latino teenagers—Oscar Vazquez, Luis Aranda, Christian Arcega, and Lorenzo Santillan—who won the 2004 Marine Advanced Technology Education Robotics Competition at the University of California, Santa Barbara. The teens were born in Mexico but raised in Arizona, where they attended Carl Hayden Community High School and were mentored by two inspiring science teachers, Fredi Lajvardi and Allan Cameron, who supported them to build an underwater robot and enter the competition. Their competitors were some of the best collegiate engineers in the country, including a team from the Massachusetts Institute of Technology. The teenagers, each of them undocumented immigrants, raised $1,000, built their “ugly” robot out of scavenged parts, and won the competition against all odds.

Oscar, Christian, Luis, and Lorenzo, who went on to become first-generation college graduates, faced deportation, worked in the fields in Mexico, served in Afghanistan, and became inspirational figures in the DREAMers movement. As the students at STEM Academy Middle School learned about the story told in Davis’s book and viewed both a documentary and a feature film depicting the team’s story, they not only discussed how they felt inspired by the story, they also used some of the ideas from the story in their own team robotics projects.

Resources

Jack Andraka’s Web site at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link22.

The Arizona Republic article “Carl Hayden Robotics Team Inspires MIT’s ‘Dreamers’” https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link23.

The documentary film about the Carl Hayden Robotics Team, *Underwater Dreams* at https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link24.

When teachers—and the broader educational community—openly acknowledge and value who students are as individuals and as members of communities and seek to integrate and build on the cultural and linguistic resources students bring to school, they promote positive relationships in classrooms, positive self-images in students, and a deep respect for diversity among all students (Gay 2002; Ladson-Billings 1995; Nieto 2008). These dispositions and actions are critical for supporting all learners to achieve their full potential. Some additional resources for implementing culturally and linguistically responsive pedagogy include the following:

- Ed Change: Resources for building equitable schools, communities, and organizations (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link25)
- So Just: A collection of historic speeches, songs, poetry, and essays on human rights and social justice (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link26)
- Teaching for Change: Tools to create schools where students learn to read, write, and change the world (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link27)
- Teaching Tolerance: A place for educators to find thought-provoking news, conversation, and support for those who care about diversity, equal opportunity, and respect for differences in schools (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link28)
- National Organization of Gay and Lesbian Scientists and Technical Professionals: A Web site providing education, advocacy, professional development, networking, and peer support for lesbian, gay, bisexual, transgender, and queer individuals in science and technology, engineering, and mathematics (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link29)
- MAES-Latinos in Science and Engineering: The foremost Latino organization for the development of STEM leaders in the academic, executive, and technical communities (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link30)
- Society of Hispanic Professional Engineers: A society whose mission is to empower the Hispanic community to realize its fullest potential and to impact the world through STEM awareness, access, support, and development (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link31)
- Benjamin Banneker Institute for Science and Technology: Resource working to identify, create, and/or support pilot projects designed to demonstrate the effectiveness of the most promising approaches to address the low performance and participation rates of African Americans in science- and math-related studies and professions (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link32)

Integrated and Designated ELD and STEM

The CA NGSS call for all students, including ELs, to engage in the science and engineering practices, which are language and literacy intensive. The CA NGSS practices require students to engage in cognitively and linguistically demanding tasks, including (but not limited to) the following:

- Reading analytically (e.g., science textbooks, research articles, arguments, Web pages, biographies of scientists) to gain or extend ideas, integrate those ideas with thinking from other sources, or assess the reasoning and evidence used to support a claim
- Discussing ideas in collaborative conversations in order to explore questions; explain, develop, or refine understandings; or argue for a particular position, using relevant evidence
- Writing concisely in a variety of genres (e.g., science journal, formal explanation) to record, organize, synthesize, and communicate their ideas
- Interpreting visual depictions of scientific phenomena and data (e.g., models, graphs, diagrams) and visually representing their own understandings in deliberate ways (e.g., determining what data to show in a table, identifying the best visual representation of concepts or data)

Each of these tasks helps students to refine and deepen their understandings of science content and simultaneously expands their ability to use the language of science when they express their ideas. These science discourse practices also present challenges for the teachers of EL students since ELs are not only learning science and the language of science but also English as an additional language. Research suggests that there are tangible ways that teachers can support ELs to fully engage in academic instruction as they develop advanced levels of English in science. This research, summarized below, suggests that science instruction should include a strong focus on several critical areas.

Critical Areas of Effective Science Instruction for English Learners

Effective instruction for ELs in science classrooms includes a strong and integrated focus on

- **meaningful interactions with intellectually challenging content and tasks** that motivate learners, stimulate their thinking and curiosity, and extend their understandings;
- **academic language and disciplinary literacy** and their explicit instruction and frequent use;
- **strategic scaffolding** that is both planned and "just-in-time," based on learner needs, and designed to move learners toward self-regulation and independence;
- **respect** for **and resourcefulness** about the cultural and linguistic knowledge EL students bring to school.

(Based on Anstrom et al. 2010; Cuevas et al. 2005; DiCerbo et al. 2014; Fang, Schleppegrell, and Moore 2013; Fradd et al. 2001; Genesee et al. 2006; Greenleaf et al. 2011; Gomez-Zwiep et al. 2011; Lee 2005; Lee, Quinn, and Valdés 2013; Moje 2007; Spycher and Linn-Nieves 2014.)

The importance of designing and providing STEM instruction for ELs that incorporates meaningful interactions with intellectually challenging content and tasks that motivate learners, stimulate their thinking and curiosity, and extend their understandings has been demonstrated in multiple studies. Meaningful interaction in K–12 science could include generating and investigating questions about topics that matter to the students themselves and the local community (e.g., the health of ecosystems, air quality) using multiple methods (e.g., observing phenomena, interviewing experts and community members, carefully reading and discussing research). It could also include engaging in structured, collaborative tasks (e.g., a conversation with peers about a science journal article, constructing a written argument with a peer, creating a mixed-media presentation in small groups). These types of learning activities are common in expanded-learning programs and can be leveraged as an important resource by classroom teachers.

California's approach to ELD for EL students is a comprehensive one. This comprehensive model includes both integrated and designated ELD, which means that all EL students should receive CA ELD standards-based instruction that is integrated into STEM instruction and also designated CA ELD standards-based instruction during a protected time and in such a way as to meet their particular language learning needs. This model, as it related to STEM, is depicted in table 10.2.

Table 10.2. Integrated and Designated ELD

STEM instruction with integrated ELD (throughout the day):	↔	Specialized instruction for ELs at a *targeted* time, based on English language proficiency levels and English language learning needs:
Integrated ELD		**Designated ELD**
All STEM teachers with ELs in their classrooms use the CA ELD Standards *in tandem with* the focal CA NGSS, related CA CCSS for ELA/Literacy, and other content standards.		A protected time during the regular school day in which teachers use the CA ELD Standards as the focal standards in ways that build *into and from STEM content instruction* in order to develop critical language ELs need for STEM learning in English.

Children and youth who are ELs face the unique challenge of learning English as an additional language[8] at the same time as they are learning science content through English.[9] This challenge creates a dual responsibility for all K–12 teachers of ELs. The first responsibility is to ensure that all ELs have full access to the grade-level, intellectually rich STEM curriculum. The second is to ensure that ELs rapidly develop advanced levels of English in science, the type of English that is necessary for success with academic tasks and texts in the sciences. To fulfill this dual responsibility, comprehensive ELD—*both* integrated ELD *and* designated ELD—should be provided to all EL students.[10]

STEM instruction *with integrated ELD* means that STEM teachers use the CA ELD Standards for guidance when they plan instruction, provide instruction, and reflect on student learning (and their own instructional practice during instruction) following instruction. Using the CA ELD Standards in planning involves many things, including identifying the language demands of tasks and texts and then determining which CA ELD Standards are most supportive for designing appropriate learning tasks and *planned* scaffolding for ELs at different English language proficiency (ELP) levels. For example, teachers might use a cluster of CA ELD Standards to decide how to group students for collaborative conversations (ELD.PI.I) so that, for example, an EL student at the early

8. The term *English as an additional language* is used intentionally to signal that an explicit goal in California is for ELs to add English to their linguistic repertoires and maintain and continue to develop proficiency in their primary language(s).
9. Some ELs are enrolled in alternative bilingual programs where they may be exclusively learning science in their primary language or learning science in both their primary language and English.
10. *Integrated* and *designated* ELD may be unfamiliar terms. These new terms now encompass elements of previously used terms such as *sheltered instruction, SDAIE,* or *dedicated ELD.* It is beyond the scope of this framework to identify all previously used or existing terms, and readers should read the framework carefully to determine how the new terminology reflects or differs from current terms and understandings.

emerging ELP level is in a group with a student who speaks their primary language (and can serve as a *language broker* when needed), as well as students who speak English proficiently so that they can benefit from these English language models.

Integrated ELD during science has been found to be particularly effective for EL students because these approaches typically afford EL students opportunities to

- learn science content and English through meaningful interactions (e.g., through a collaborative task, taking notes in a science journal);
- communicate about science through English in multiple ways (e.g., in writing, orally, using graphics, kinesthetically, using technology);
- use the language of science in authentic and relevant ways, including specialized grammatical structures and vocabulary;
- learn about how science uses specialized language to communicate effectively (Lee et al. 2006; Gomez-Zwiep et al. 2011; Merino et al. 2014; Spycher 2009).

During the planning for instruction, teachers might use the CA ELD Standards to design language frames to support EL students to write or orally share about what they learned in a collaborative task (e.g., We discovered that surface mining affects ______. Characteristics of ___ include _____.) Teachers can design these language frames (and other scaffolding techniques) in ways that support students to use more specialized scientific language (ELD.PI.12a, ELD.PII.3, 7) and practice adapting their language choices (ELD.PI.4) to science. Language frames should be used judiciously and are most useful when they are open (allowing for elaboration, rather than merely inserting one word) and provided after students have engaged in content- and language–rich tasks—tasks during which ELs use the language they feel most comfortable using). The use of language frames should support, rather than inhibit, the development of both content understanding and language.

Critically, planning for STEM instruction with integrated ELD begins with thinking about the science content first, using the CA NGSS as guidance. This maintains the integrity and rigor of the lesson or unit. Teachers may want to use framing questions when they plan lessons and units, such as those provided in table 10.3.

Table 10.3. Framing Questions for Science with Integrated ELD

FRAMING QUESTIONS FOR ALL STUDENTS	ADD FOR ENGLISH LEARNERS
• What are the big ideas and culminating performance tasks of the larger unit of study, and how does this lesson build toward them? • What are the learning targets/performance expectations for this lesson, and what should students be able to do at the end of the lesson? • Which clusters of CA NGSS and CA CCSS for ELA/Literacy (and other content standards) does this lesson address? • What background knowledge, skills, and experiences do students have related to this lesson? • How complex are the texts and tasks to be used? What are the language demands in these tasks and texts? • How will students make meaning with the science content, communicate effectively about it, and develop language through the lesson or unit?	• What are the English language proficiency levels of the students? • Which CA ELD Standards would amplify the CA NGSS and CA CCSS for ELA/Literacy in this lesson/unit (at students' English language proficiency levels)? • What language might be new for an individual or groups of students and/or present particular challenges? • How will students interact in meaningful ways through English? • How will students learn about how English works in science?
• What types of scaffolding, accommodations, or modifications will individual students need for effectively engaging in the lesson tasks? • How will learning be monitored during and after the lesson, and how will that inform instruction?	

Source: Adapted from CDE 2014a

Using the CA ELD Standards during instruction involves providing just-in-time scaffolding where teachers are able to observe their students carefully and step in to provide the appropriate levels and types of support when needed—and also knowing when not to step in too soon. Science learning affords many opportunities to engage in formative assessment, a process and an integral part of instruction, which provides both teachers and students ongoing feedback they can use to fine-tune instructional strategies or adjust learning approaches. The CA ELD Standards teachers use as they plan instruction can also help them determine what they are looking for in student learning and how they will provide just-in-time scaffolding to ELs when needed. By reflecting on the student learning directly relevant to the CA ELD Standards, as well as the effectiveness of the scaffolds and strategies used with individual students during instruction, teachers can further EL students' success in STEM coursework. This reflective practice allows teachers to make intentional choices about next steps for their EL students.

Designated ELD is a protected time where ELs receive targeted instruction based on their particular language learning needs, in ways that build into and from content instruction. There are different approaches to providing such instruction to build into and from STEM instruction. For example, in elementary school, teachers might work collaboratively to "regroup" their EL students for brief periods of time during the day, such that one teacher provides instruction to EL children at the Emerging ELD level, another teacher provides instruction to children at the Expanding level, and still another works with children at the Bridging level. In secondary schools, grouping EL students becomes more complex, as educators also ensure that EL students remain engaged in academic instruction, including STEM, and partake in courses such as the arts. All schools should make informed and intentional decisions about how they provide both integrated and designated ELD to all of their EL students. For examples of approaches see the Integrated and Designated ELD section of this chapter, elsewhere in this framework, and the *CA ELA/ELD Framework.*

All students need to develop the abilities to engage with academic language and disciplinary literacy in science, and for ELs, schools and expanded learning opportunities play a critical role in supporting this development in English. A focus on the language of science is critical for ELs' success in the discipline of science. This is because the English language is the medium in which most science teaching and learning takes place in schools, the medium through which we transform and develop our thinking from everyday, or common sense, understandings of phenomena, to more scientific ones. Content knowledge is embedded in the language used in STEM texts and tasks (e.g., in the domain-specific vocabulary and complex grammatical structures in both oral and written discourse, as well as in the language used in media and visuals). By the same token, language conveys the science content knowledge writers and speakers wish to impart (e.g., the way in which an argument is constructed to persuade others to accept a claim, how data are represented through language). This dual relationship demonstrates how language and content are inextricably linked, how language is a resource for construing meaning, and how language is not merely facts written down (Halliday 1993). In other words, language and literacy are fundamental to both scientific understanding and scientific literacy.

For these and other reasons, language has been referred to as the *hidden curriculum,* and when the language of science remains hidden to EL students, science learning is hindered. From this perspective, success in STEM has much to do with success in language. Teachers who understand how English works to make meaning in science—that is, what the lexical, grammatical, and discourse features of oral and written science texts are and how they convey particular meaning—are in a better position to guide their EL students to more fully understand these features. Explicit attention to the language of science—in purposeful ways that focus on building language knowledge and skills in the service of building content knowledge—can support their students to fulfill their linguistic and academic potential in science subjects.

Scaffolding

Scaffolding may benefit many students, but it is essential for EL students, students with disabilities, struggling readers, and other students who may occasionally need moderate to substantial assistance. Teachers should provide strategic scaffolding adjusted to students' particular learning needs, to ensure new concepts and tasks remain within each student's zone of proximal development (Vygotsky 1978). When scaffolding instruction and tasks for EL students, teachers should use the CA ELD Standards as a guide. Scaffolding is focused on supporting students' self-regulation, gradually decreasing support so that students can become independent with science tasks and texts (Wood, Bruner, and Ross 1976). In recent reviews of scaffolding, a conceptual model for scaffolding with three essential characteristics has emerged: contingency, fading, and transfer of responsibility (Van de Pol et al. 2010 as cited in Merino et al. 2014).

> Contingent scaffolds are tailored to learners at their individual level of performance to the degree possible as differentiated support. Fading refers to the need for teachers to reduce the support as students move toward independent performance. Transfer of responsibility is viewed as an essential step to ensure that students move toward independent performance. This view of scaffolding suggests that the teacher must adapt support to fit students' needs on an ongoing basis. (Merino et al. 2014, 24)

As Merino et al. (2014) note, fading—the gradual withdrawal of the scaffolding—is a critical, yet often misunderstood and neglected step in the scaffolding process. This sometimes results in a sense of *overscaffolding,* where too much support and not enough productive struggle becomes a metaphorical crutch that keeps students reliant on teacher assistance. The alternative is to structure opportunities for students to attempt and complete tasks increasingly independently; by doing this, the teacher provides a ladder students can make use of toward independence. Scaffolding does not change the intellectual challenge of the task but instead allows learners to successfully participate in or complete the task in order to build the knowledge and skills to be able to perform the task independently at some future point.

Scaffolding for all students is composed of two main categories: planned and just-in-time. *Planned scaffolding*[11] is what teachers prepare and do in advance of teaching to

11. There are many ways to categorize scaffolding. The terms used here are adapted from Hammond and Gibbons (2005), who refer to *designed-in* and *interactional* scaffolding. Designed-in (or planned) scaffolding refers to the support teachers consciously plan in advance. Interactional scaffolding refers to the support teachers provide continuously through dialogue during instruction or other interaction.

promote access to academic and linguistic development. This planned scaffolding in turn allows teachers to provide *just-in-time scaffolding* during instruction. This flexibly meets students' needs. This type of scaffolding occurs when teachers engage in in-the-moment formative assessment, closely observing their students' responses to instruction and providing support, as needed. Examples of planned and just-in-time scaffolding as they pertain to ELs are provided below.

Planned and Just-In-Time Scaffolding

Examples of planned scaffolding include, but are not limited to, the following:

- Taking into account what students already know, including primary language and culture, and relating it to what they are to learn
- Selecting and sequencing tasks, such as providing adequate levels of modeling and explaining, and ensuring students have opportunities to apply learning (e.g., guided practice)
- Planning for opportunities to frequently check for understanding during instruction, as well as thinking ahead about how to gauge progress throughout the year
- Choosing texts and tasks carefully for specific purposes (e.g., to motivate, build content knowledge, provide opportunities for students to grapple with and discuss new concepts, expose students to technical language, or to challenge students to work at a higher level of text complexity)
- Providing a variety of opportunities for collaborative group work where all students have an equitable chance to participate
- Constructing questions that are worth discussing and that promote critical thinking and extended discourse
- Using a range of information systems, such as graphic organizers, diagrams, photographs, videos, or other multimedia to enhance access to content
- Providing students with language models, such as sentence frames/starters, academic vocabulary walls, language frame charts, exemplary writing samples, or teacher language modeling (e.g., using academic vocabulary or phrasing)

Examples of *just-in-time scaffolding* include, but are not limited to, the following:

- Prompting a student to elaborate on a response in order to clarify thinking or to extend their language use
- Paraphrasing a student's response and including target academic language as a model while, at the same time, accepting the student's response using everyday language or the variation of English students speak at home
- Adjusting instruction on the spot based on data collected during frequent checking for understanding
- Linking what a student is saying to prior knowledge or to learning to come (previewing)

While scaffolding is an integral component of effective instruction for all students, the CA ELD Standards provide general guidance on degrees of scaffolding for ELs at different English language proficiency levels. In the CA ELD Standards, the three overall levels of scaffolding that teachers provide to ELs during instruction are *substantial, moderate,* and *light*. ELs at the Emerging level of English language proficiency will generally require more substantial support to develop capacity for many academic tasks than will students at the Bridging level. This does not mean that these students will always require scaffolding for every task.

English learners at every level of English language proficiency will engage in some academic tasks that require light or no scaffolding because they have already mastered the requisite skills for the given tasks; similarly, students will likely also engage in some academic tasks that require moderate or substantial scaffolding because they have not yet acquired the cognitive or linguistic skills required to complete the task. For example, when a challenging academic task requires students to extend their thinking and stretch their language, students at Expanding and Bridging levels of English language proficiency may also require substantial support. Teachers and education support professionals need to provide the level of scaffolding appropriate for specific tasks and learners' cognitive and linguistic needs, and students may need more or less support, depending on these and other variables.

English learners bring unique resources to the science classroom: their primary languages and cultures. All teachers should demonstrate respect and resourcefulness in leveraging these linguistic and cultural resources as "funds of knowledge" (Moll and Gonzalez 1994) for learning science. Teachers can do many things to support ELs as they develop English through the strategic use of primary-language resources. For example, during collaborative conversations with peers, ELs who are relatively new to English can share ideas in their primary language as they gain proficiency and confidence in learning how to express the same ideas in English. ELs who can read in their primary language can read science texts in that language to maintain grade-level proficiency. In addition to allowing the use of the primary language in classrooms, teachers can provide brief oral or written translations when appropriate and draw ELs' attention to cognates (words that are the same or similar in spelling and share the same meaning in the primary language and in English).

Integrated and Designated ELD in Action

The CA ELD Standards were designed to support all content teachers as they plan and provide instruction for ELs that focuses on each of these critical areas: structuring meaningful interactions with intellectually challenging content and tasks and developing academic language and disciplinary literacy, while providing strategic scaffolding. The standards describe the key knowledge, skills, and abilities in critical areas of ELD that

ELs need to develop in order to be successful in school. Part I of the CA ELD Standards, Interacting in Meaningful Ways, provides guidance on how to support ELs to engage meaningfully with science content in collaborative, interpretive, and productive ways. Part II of the CA ELD Standards, Learning About How English Works, offers teachers guidance on how to support their ELs to develop deep understanding of and proficiency using academic English in a range of disciplines, including science. The goal of Part II of the CA ELD Standards is to guide teachers to support ELs in ways appropriate to a student's grade level and English language proficiency level (Emerging, Expanding, Bridging), to do the following:

- Make meaning from the written and oral texts they encounter in order to better understand them
- Make informed and deliberate choices about how to use English effectively and purposefully, based on discipline, topic, audience, task, and type of communication (e.g., a conversation between peers, a written argument, a science journal entry)

The following snapshots illustrate brief examples of integrated and designated ELD in the content area of science and are not meant to be prescriptive or to provide a comprehensive portrait of a comprehensive approach to ELD. Lengthier examples of integrated and designated ELD can be found in the grade-span chapters of this framework as well as in the *CA ELA/ELD Framework.*

Access and Equity Snapshot 10.6: Learning about Insects in Kindergarten—Integrated and Designated ELD in Life Science

Mr. H taught science daily, and he frequently provided opportunities for his kindergarteners to explore science concepts using models and real objects (e.g., real earthworms and soil, toys with wheels). During science instruction, the children regularly observed the natural world in the school garden, at the science literacy station, and elsewhere. They recorded their observations in their science journals and frequently discussed their observations and ideas with one another in pairs and small groups. Mr. H also read aloud daily multiple science informational texts and sometimes showed videos and other media containing information on the science concepts in focus. Some of the language in the science texts and tasks that were new for many of his EL students were domain-specific vocabulary (e.g., *soil, root, stem, germination, sprout*), general academic vocabulary (e.g., *emerge, develop, delicate*), and prepositional phrases (e.g., *in the ground, for three weeks*).

Access and Equity Snapshot 10.6: Learning about Insects in Kindergarten— Integrated and Designated ELD in Life Science

Mr. H provided structured opportunities for his EL students to use the new science language they were learning, and he used the CA ELD Standards to guide his instructional planning and to ensure that he was integrating ELD meaningfully during science instruction. For example, during a science unit on insects, in their "insect discovery lab," the students observed real insects, including butterflies, ladybugs, mealworms, ants, grasshoppers, and walking sticks, as well as models of insects (e.g. large plastic models of ants and bees, for example). During their observations, Mr. H encouraged the students to describe to one another what they observed, using whatever language they were comfortable using and as much detail and precision as they could regarding the insects' bodies and behaviors. Occasionally, as he listened to the students' conversations and determined particular students were capable of using more technical terms, such as domain-specific vocabulary they had been learning from books and videos (e.g., *antennae, wings, abdomen*), he gently prompted them to use the new language. Sometimes, he asked the students to use open sentence frames in their discussions, frames that contain domain-specific and general academic vocabulary, as well as increasingly complex grammatical structures (e.g., *When the bee lands on the flower,* ___). Each day, he asked the students to record what they observed and discussed in their science observation logs, using drawings, labels, and short observation notes. This use of the CA ELD Standards during science instruction (with **integrated ELD**) supported Mr. H's students who are ELs (as well as other students) to adopt and use the new language of science in meaningful ways.

For **designated ELD** instruction, Mr. H varied his approaches depending on the group with which he was working. For example, he discussed with all of the EL children different ways in which they could select particular language resources (such as vocabulary or grammatical structures) and expand and enrich their ideas to be more precise and detailed when they orally described the insects they were learning about. However, he knew from observing his students during their conversations what new language individual students were ready to be encouraged to use more strategically, and he used the CA ELD Standards to plan these differentiated lessons to focus students' attention on the language of science.

For students at the Emerging level of English language proficiency—those who are very new to English—sometimes he structured opportunities for them to use precise, domain-specific vocabulary (e.g., *larva, thorax*) to be more precise in their oral descriptions of the insects. On other days, he encouraged them to add a familiar adjective (e.g., *big, small, green*) to provide more detail. On some days, he encouraged the students to use simple prepositional phrases (e.g., *on the leaf, in the tunnel*) so that they could be more specific when they discussed and wrote about what they had observed. Mr. H worked with the small group of his EL students at the Emerging level at the teacher table while the other

Access and Equity Snapshot 10.6: Learning about Insects in Kindergarten—Integrated and Designated ELD in Life Science

students in the class worked together in pairs or triads at science literacy stations. He provided large photos of insects in their natural habitats, models, hand-drawn charts, and real insects in contained environments (e.g., butterfly house) to prompt the students to share words, phrases, and sentences about what they had observed, which he charted in front of the children. He occasionally modeled for them, and he encouraged them to use the new language they were learning and using during the daily teacher read-alouds, chants and songs, and science tasks. When he worked with his EL students at the Expanding level, he also used visuals and highly interactive tasks, focusing on oral language development but also incorporating some print. Using the CA ELD Standards, he stretched this group of students to extend their language use in more sophisticated ways. For example, in one lesson, he showed the students how to expand and enrich their ideas by adding prepositional phrases (e.g. *with full pollen baskets and around the flowers*) to sentences such as *The bee is flying*. Through careful observation, he knew this group of students was ready to use this type of language, and he explained to them how adding these phrases would give listeners and readers much more detail about the observations they were making, thus providing them with a communicative purpose for using the new language. Mr. H said that adding these details when they tell and write, helps the audience create a clearer and more interesting picture of the insects.

Mr. H used the pocket chart as he recorded the ideas the students offered for enriching and expanding a base sentence, and then the group discussed how to put the ideas together. Mr. H read and reread the phrases and sentences with the students as he knew that not all of the students were able to independently read them.

Access and Equity Snapshot 10.6: Learning about Insects in Kindergarten—Integrated and Designated ELD in Life Science

The bee is flying. (base sentence) The bee drinks.		
with full pollen baskets	around the flowers	in the garden
with four wings	around the classroom!	in the vegetable garden
The bee with the full pollen baskets is flying. The bee is flying around the flowers.		
The bee with full pollen baskets is flying around the flowers.		
The bee with full pollen baskets is flying around the flowers in the vegetable garden.		
The bee with full pollen baskets is flying around the classroom!		

As the lesson progressed, Mr. H noted that phrases that started with the word *with* told more about the bee, so those phrases would go right after the word *bee*. Samuel noticed that phrases that started with the words *around* and *in* were telling where the bee was flying, and the group agreed that those phrases would go somewhere after the word *flying* but not after *bee*. The children experimented with orally expanding and enriching other base sentences using photographs and other visuals.

On other days, Mr. H worked with each of his groups of EL students to connect their ideas by combining sentences. He guided students at the Emerging level of English language proficiency to construct the following types of compound sentences:

> *Bees are insects. Bees make honey.* → *Bees are insects,* **and** *they make honey.*

Access and Equity Snapshot 10.6: Learning about Insects in Kindergarten—Integrated and Designated ELD in Life Science

When he worked with his EL students at the Expanding level of English language proficiency, he guided them to construct the following types of complex sentences, which were slightly more grammatically complex:

> *Bees are insects. Bees are special kinds of insects. Bees make honey.* → *Bees are special kinds of insects* **that** *make honey.*

Mr. H encouraged all of his EL students to use the language they had been learning in designated ELD during science. He observed them carefully as they engaged in lively discussions and recorded their ideas in their journals. He noticed that over time many of the students were "taking up" the language of science and using it meaningfully to both deepen their understandings of the concepts and to express their ideas effectively.

Source: Adapted from CDE 2014a, Snapshot 3.6

CA NGSS: K LS1-1—Use observations to describe patterns of what plants and animals (including humans) need to survive.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
[SEP-4] Analyzing and Interpreting Data Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.	LS1.C: Organization for Matter and Energy Flow in Organisms • All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	[CCC-1] Patterns Patterns in the natural and human-designed world can be observed and used as evidence.

Related CA CCSS for ELA/Literacy: RI.K.1–2; SL.K.2, 3, 5; W.K.2; L.K.4, 6

CA ELD Standards: ELD.PI.K.6, 12b; ELD.PII.K.4–6

Access and Equity Snapshot 10.7: Learning about Earthquakes in the Seventh Grade—Integrated and Designated ELD in Earth Science

The seventh-graders in Ms. L's science class were learning about plate tectonics, and they had gathered information about how plate tectonics relates to earthquakes in California. The students had already engaged in several tasks to learn about the topic, including working in pairs to create a labeled diagram to show the plates' locations and movements, discussing in small groups the texts they had read and Web sites they had viewed on the topic, and writing descriptions, explanations, and summaries in their science journals. Their conversations were particularly animated as the school was located not far from the epicenter of a recent earthquake, and the students had much to say about their experiences.

Ms. L worked collaboratively with the school's ELD specialist, Mr. T. During student-led conversations, both teachers had noticed that eight of their EL students at the Expanding level of English language proficiency did not seem to be fully participating in the conversations. They had also noticed that these students' science journal entries were very short, with simple sentences that did not contain much detail or precision. The teachers determined that, while the students were very comfortable using conversational English in class discussions and writing about things they were very familiar with, the students did not seem to be using the language of the new science topic in conversation or writing. Based on their observations, the teachers worked together, using the CA ELD Standards and the CA NGSS, to identify where to focus their instructional attention so that this group of students could fully benefit from the science instruction as the unit progressed and could express their ideas effectively using the language of the science topic.

In their analysis of the students' science journal entries and conversations, Ms. L and Mr. T found that some of the language they would like to see the students using, because it is language that is important for understanding the science, was missing. This language included domain-specific vocabulary (e.g., *mantle, lithosphere, subduction*), general academic vocabulary (e.g., *distribution, movement, relative*), adverbials (e.g., *along breaks in the crust, at the rate of*), and complex sentence structures that show relationships between ideas (e.g., a cause-effect relationship as in: *When one plate is subducted under the other plate, a deep ocean trench is produced.*). The teachers felt that their EL students were capable of learning these more academic ways of using English in science and that it was critical for them to feel confident using the language to effectively express their understandings. Moreover, the teachers felt that the students' understandings of the plate tectonics might be adversely affected if they did not fully understand the science language.

The teachers decided that Ms. L would focus on explicitly teaching some of the critical domain-specific and general academic vocabulary during instruction for all students as she felt that most of the students in the class would also benefit from more instructional attention to the words. They decided that Mr. T would work with the group of eight ELs at

Access and Equity Snapshot 10.7: Learning about Earthquakes in the Seventh Grade—Integrated and Designated ELD in Earth Science

a designated time during the week while the rest of the class was engaged in collaborative tasks or working with Ms. L in a small group. He would address the complex grammatical structures of some of the sentences students have encountered in their science texts. He strategically selected sentences that were critical for understanding the science, that were particularly challenging to understand due to their grammatical complexity, and that contained vocabulary and other language features (e.g. long noun phrases) that the teachers would like to see more of in the students writing and speaking.

Mr. T began by explaining to the students that the types of sentences they would be analyzing were challenging to disentangle (sometimes even for him). Next, he showed the students a technique he used when he came to a challenging sentence on an unfamiliar topic. The first thing he does is to stop and "unpack" the sentence to get at all of the meanings in it. He modeled how to do this with a sentence from a text the students had read earlier in the week.

> "The relative amount of energy released by an earthquake, its magnitude, can be measured by an instrument called a seismograph."

Mr. T thought aloud as he unpacked the meanings in the sentence using everyday conversational English (e.g., "There's some energy, and it's getting released. Not all of it is getting released, only a certain amount"). He explained the meaning of the word *relative,* which in the science text had a different meaning than the way the word is used in everyday conversations. He reminded them that they had seen the word *magnitude* many times already in the unit, and he showed them how the text actually provided the meaning of the word right before it. He told them that this way of providing descriptions of technical science words, appositives, is something they will see often in their science texts. He invited the students to join in and tell him what other meanings they saw, and he wrote all of their ideas on chart paper. Next, he had the students work in pairs to unpack other sentences from the texts they had read. After a few minutes, he asked the partners to compare what they found with the other pairs, and he facilitated a discussion about all the different meanings the students had found in the densely packed sentences.

Once they had focused on all of the meanings that were packed into the sentences, Mr. T showed the students why sentences such as the ones he had selected were sometimes difficult to understand. On another day, he focused on long noun phrases since many science texts contain this type of language to provide detail and precision about things, or *nouns*. He explained to the students that a *long noun phrase* is simply a noun with words that come before or after it to provide more information about the noun. He showed them the boundaries of the noun phrases in one of the sentences the students just unpacked by underlining them, and he identified where the *main noun* was and

Access and Equity Snapshot 10.7: Learning about Earthquakes in the Seventh Grade—Integrated and Designated ELD in Earth Science

highlighted it in bold. He pulled out just the main nouns of each long noun phrase and created a grammatically simpler sentence, which he wrote below the original one. The sentence Mr. T discussed with the students, with the long noun phrases in italics and main noun in bold italics, is provided below.

> *The relative* ***amount*** *of energy released by an earthquake, its magnitude,* can be measured by *an* ***instrument*** *called a seismograph.*
>
> *The* ***amount*** can be measured by *an* ***instrument****.*

Mr. T facilitated a discussion with the students about how the words that come before or after the main noun provide more detail and precision and enhance the meaning of the entire sentence.

Sylvia shared, "With the simpler sentence, it was easy to understand it, what it means. But there was a lot of details missing, and I think the details are important to understand how the earthquakes release an amount of energy, called magnitude. And the amount of energy, you can measure it with a special instrument called a seismograph. If you don't have all those details, you can't really understand what magnitude is."

Mr. T asked the students why they thought that unpacking the meanings in sentences and finding the boundaries of the long noun phrases might be useful for them.

Ana responded, "I think it could help us slow down so we can really understand what the important things in the sentences are, what the details are. There are a lot of hard words in the sentences, but if I know some of them and can figure out how they are working together, maybe I can understand what the sentence means better."

Chue added, "When we looked at how the long noun phrases, how they add a lot more information, I think I can use some of those ideas, some of those words, when we have to write in the science journal."

Mr. T acknowledged these comments and challenged all of the students to (a) begin using the sentence-unpacking technique from time to time when they come to a challenging sentence and (b) to use more long noun phrases when they are writing about or discussing plate tectonics and earthquakes.

Ms. L and Mr. T met later to reflect on how their approach worked. They shared that they would both observe the students closely in discussions and also look at their science journals to see if they were "taking up" the language the teachers had focused on during instruction.

Sources: US Geological Survey (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link33)

Adapted from CDE 2014a, Snapshot 6.6.

CA NGSS: MS-ESS2-2: History of Earth: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
[SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	ESS2.A: Earth's Materials and Systems The planets' systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. ESS2.C: The Role of Water in Earth's Surface Processes Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	[CCC-3] Scale Proportion and Quantity Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

CA CCSS for ELA/Literacy: RI.7.3-4; L.7.1, 3, 6

CA ELD Standards: ELD.PI.7.6a, c, 8, 12a–b; ELD.PII.7.4–7

For more information on integrated and designated ELD and for additional examples of instruction, see the grade-span chapters in this framework as well as the *California ELA/ELD Framework.*

Supporting Students Experiencing Difficulty with Literacy in Science and Engineering

In this section, guidance is provided regarding research-based instruction for students who are experiencing difficulty in science and engineering course work. Before any approach to supporting students experiencing difficulty in STEM course work is undertaken, the reason for the difficulty must be accurately diagnosed. As for students with disabilities, the largest group of students is composed of those with specific learning disabilities, which often involve difficulty reading. In addition, many students without disabilities demonstrate challenges with reading their science and engineering texts. Sometimes, disrupted prior learning experiences may have resulted in gaps in foundational knowledge. Low motivation and engagement can also lead to difficulties in succeeding in STEM learning.

What is appropriate for individuals will vary depending on many factors, including the particular academic learning needs, age, language proficiency in English and in the primary language, cultural and linguistic backgrounds, and past experiences (including prior schooling) of individual students. Instruction should take place in the context of a supportive, respectful environment that communicates high expectations of all students. Furthermore, attention needs to be paid to student motivation and to students' social and emotional learning needs, as this enhances their academic development.[12]

Maintaining students' positive engagement with school is critical for all students—and even more so for students who might feel alienated or unsuccessful. Helping students develop a *growth mind-set,* in which they believe that through effort and instruction their intellectual ability can grow (Dweck 2010), is essential. Some general guidelines for establishing learning environments that are motivating and engaging for all students are presented below.

12. To learn more about social and emotional learning, see the Collaborative for Academic, Social, and Emotional Learning (CASEL) Web site (https://www.cde.ca.gov/ci/sc/cf/ch10.asp#link34), which includes a library of resources for teachers and leaders.

Motivation and Engagement

Educators should keep issues of motivation and engagement at the forefront of their work to assist students in developing a growth mindset and finding academic success in school. The panel report *Improving Adolescent Literacy: Effective Classroom and Intervention Practices* (Kamil et al. 2008) makes clear the importance of addressing motivation and engagement throughout the grades and recommends the following practices in classrooms with adolescents:

1. Establish meaningful and engaging content-learning goals around the essential ideas of a discipline as well as the specific learning processes students use to access those ideas.
   - Monitor students' progress over time as they develop more control over their thinking processes relevant to the discipline.
   - Provide explicit feedback to students about their progress.
   - Set learning goals. When students set their own goals, they are more apt to fully engage in the activities required to achieve them.
2. Provide a positive learning environment that promotes students' autonomy in learning.
   - Allow students some choice in learning tasks.
   - Empower students to make decisions about topic, forms of communication, and selections of materials.
3. Make learning experiences relevant to students' interests, everyday life, or important current events (Guthrie et al. 1999).
   - Look for opportunities to bridge the activities outside and inside the classroom.
   - Find out what your students think is relevant and why, and then use that information to design instruction and learning opportunities that will be more relevant to students.
   - Consider constructing an integrated approach to instruction that ties a rich conceptual theme to a real-world application.
4. Build in certain instructional conditions, such as student goal setting, self-directed learning, and collaborative learning, to increase reading engagement and conceptual learning for students (Guthrie et al. 1999; Guthrie, Wigfield, and VonSecker 2000).
   - Make connections between disciplines, such as science and social studies or English language arts, taught through conceptual themes.
   - Make connections among strategies for learning, such as searching, comprehending, interpreting, composing, and teaching content knowledge.
   - Make connections among classroom activities that support motivation and social and cognitive development.

Contributing to the motivation and engagement of diverse learners, including English learners, is the teachers' and the broader school community's recognition that students' primary languages, dialects of English used in the home, and home cultures are resources to value in their own right and also to draw upon in order to build proficiency in English (De Jong and Harper 2011, 73–90; Lindholm-Leary and Genesee 2010). Teachers can do the following:

- Create a welcoming classroom environment that radiates respect for individual students, their families, their communities, and cultural and linguistic diversity in general.
- Get to know students' cultural and linguistic backgrounds and how individual students interact with their primary language, home dialect, and home cultures.
- Use the primary language or home dialect of English, as appropriate, to acknowledge them as valuable assets and to support all learners to fully develop academic English and engage meaningfully with the core curriculum.
- Use texts that accurately reflect students' cultural, linguistic, and social backgrounds so that students see themselves in the curriculum.
- Continuously expand one's own understandings of culture and language so as not to oversimplify approaches to culturally and linguistically responsive pedagogy.

Source: Adapted from CDE 2014a, figure 7.2

For more suggestions regarding student motivation and engagement and culturally and linguistically responsive approaches, see the CA ELA/ELD Framework.

Support for students experiencing difficulty begins with close attention to students' STEM background knowledge and skills, their academic progress over the course of the current and prior school years, and, for ELs, consideration of primary language proficiency as well as English language production and literacy skills. For students who are experiencing difficulty with literacy, teachers should attend to the guidance provided on disciplinary literacy in science in other chapters in this framework as well as to the recommendations provided in the *CA ELA/ELD Framework.* Importantly, the CA CCSS for ELA/Literacy and the CA ELD Standards are intended to provide guidance to teachers of all disciplines to support literacy development in their content course work.

Ideally, students complete the primary grades with a strong command of foundational skills; a rapidly expanding vocabulary; increasingly complex syntactic structures; a developing body of content knowledge; the ability to comprehend and communicate about a variety of text types at their grade level (including making inferences and making connections with other texts and knowledge); and an interest in engaging with a range of text types, both as consumers and composers. This early, solid foundation best positions all learners for success not only in a K–12 setting but in their eventual college and career choices.

However, even when learners receive the highest quality, differentiated first instruction, some may experience difficulty interpreting the increasingly complex science and engineering texts and content they encounter as they progress into and through secondary schooling. Science and engineering teachers can implement tangible instructional actions to support their students to engage more meaningfully with the texts used in content instruction so that students can better comprehend and convey their understanding of content knowledge (Duke et al. 2011, 51–93; Gibbons 2009; Fang, Schleppegrell, and Moore 2013; Vaughn et al. 2012):

1. Integrate strategies that support cognitive processing (e.g., self-regulation and memory activation) with academic instruction by
   - thinking aloud to demonstrate, for example, approaches to a task and reflections on a text while reading;
   - teaching students to use self-regulation strategies by, for example, asking what they do when their comprehension of a text breaks down and providing options for what they could do;
   - explicitly teaching memory enhancement techniques, such as taking notes and using graphic organizers or other text organizers to organize complex content information;
   - providing task-specific feedback (e.g., "your use of the words *refraction* and *resulted in* in your report helped you to convey your ideas very clearly to your readers") rather than person-directed feedback (e.g., "you are a good writer") so students attribute success to effort and behavior rather than personal, fixed abilities.
2. Intensify meaningful interaction with content by
   - structuring opportunities for students to work together on collaborative tasks, focusing particularly on equitable interaction as a means to increase motivation;
   - providing explicit instruction, including clear explanations and teacher modeling;
   - making instruction systematic, which includes breaking down complex skills into manageable chunks and sequencing tasks from easier to more difficult with appropriate levels of scaffolding, based on identified student needs;
   - providing students with frequent opportunities to apply what they've learned, ask questions, and take risks, with supportive and "in-the-moment" teacher feedback;
   - providing students with opportunities to apply learning through guided practice, independent practice, and peer collaboration.

3. Attend to disciplinary literacy by
   - using reading selections that serve to discuss with students how language is used in science and engineering (e.g., vocabulary, text structure and organization, how ideas are "packaged" in sentences and paragraphs);
   - providing students with opportunities to explore how science and engineering texts work (e.g., language analysis: unpacking the meanings in grammatically complex sentences; connecting text to information presented in diagrams and graphs; identifying text connectives, nominalization, and other language resources);
   - engage students in language–based activities that simultaneously build content knowledge (e.g., explicit vocabulary introduction and discussion in the context of activities and diagrams, reconstructing and deconstructing texts);
   - support and provide time for students to discuss the language and multimodal aspects of science texts and how they convey science and engineering meanings.
4. Intensify instructional time by increasing
   - frequency of instruction (e.g., extended day or school year, tutoring before or after school) and
   - length of instructional sessions (e.g., extending a 20-minute science lesson in order to provide sufficient time for discussion).

For more information on scaffolding, disciplinary literacy, reading interventions, and other topics related to supporting students experiencing challenges with literacy, see the *CA ELA/ELD Framework.*

Conclusion

The CA NGSS offer a vision of science and engineering teaching and learning that presents both opportunities and challenges for all students. California is committed to ensuring equity and access in all classrooms so that each California student can thrive in science and engineering and achieve the high standards established by the CA NGSS. Ensuring that all learners achieve their highest potential is a challenging and multi-faceted endeavor, but it is one that can be accomplished by knowledgeable, skillful, and dedicated teams of educators who work closely with families and equally dedicated communities. Our children and youth deserve no less, and our state and nation will be stronger as a result.

The academic rigor, language and literacy intensity, and high expectations of the CA NGSS may be less familiar to many teachers than conventional or traditional teaching practices, and they require shifts or refinements in teaching. These shifts are parallel to and consistent with shifts for teaching the CA CCSS for ELA/Literacy and mathematics and the CA ELD Standards. Effective implementation of the CA NGSS for all students will also require shifts in support systems established by schools and districts as the responsibility for the success of California's children and youth in science and engineering is a shared one. Critical components of support systems include effective preparation and on-going professional learning for teachers and principals that address equity and access not as an afterthought but as a regular part of the school and district culture. Other support elements include adequate time, space, and resources (e.g., equipment and consumable materials) devoted to science in all schools; public-private-community partnerships to support student science learning in and out of school time; formal and informal learning experiences coordinated among community stakeholders; and both technology resources and network infrastructures that include cyber-learning opportunities, access to digital resources, online learning communities, and virtual laboratories. To achieve equity in science and engineering, these support systems should be instilled into each and every school district and school in California.

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