"All Standards, All Students": Making Next Generation Science Standards Accessible to All Students

Next Generation Science Standards (NGSS) are being developed at a historical time when major changes in education are occurring at the national level. On the one hand, student demographics in the nation are changing rapidly, while science achievement gaps persist. On the other hand, national initiatives are emerging for a new wave of standards through NGSS as well as Common Core State Standards (CCSS) for English language arts and literacy and for mathematics. Furthermore, the participation of 26 lead states to guide the development and provide feedback to the NGSS design team suggests a high level of interest for coherent science standards among state leaders.

The chapter highlights practicality and utility of implementation strategies that are grounded in theoretical or conceptual frameworks. It consists of three parts. First, it discusses both *learning opportunities and challenges* that NGSS presents for student groups that have traditionally been underserved in science classrooms. Second, it describes effective strategies for *implementation* of NGSS in the science classroom, school, home, and community. Finally, it provides the *context* of student diversity by addressing changing demographics, persistent science achievement gaps, and educational policies affecting non-dominant student groups.

NGSS: Learning Opportunities and Demands for Non-Dominant Student Groups

NGSS offers a clear vision of rigorous science standards by seamlessly blending scientific and engineering practices with disciplinary core ideas and crosscutting concepts across K-12. In addition, NGSS makes connections to CCSS for English language arts and literacy and for mathematics. For the student groups that have traditionally been underserved in science education, NGSS offers both learning opportunities and challenges. Instead of making a long list of opportunities and challenges, major considerations are discussed below.

Inclusion of Engineering

Inclusion of engineering in NGSS has major implications for non-dominant student groups. First, NGSS reinterprets a traditional view of epistemology and history of science. For example, *Science for all Americans* stated:

> The recommendations in this chapter focus on the development of science, mathematics, and technology in Western culture, but not on how that development drew from earlier Egyptian, Chinese, Greek, and Arabic cultures. The sciences accounted for in this book are largely part of a tradition of thought that happened to develop in Europe during the last 500 years – a tradition to which most people from all cultures contribute today. (American Association for the Advancement of Science [AAAS], 1989, p. 136)

At that time, although the goal of "Science for all Americans" was visionary, the definition of science in terms of Western science while ignoring historical contributions from other cultures presented a limited or distorted view of science. Furthermore, such view was disrespectful of other cultures and could be regarded as racism. NGSS, by emphasizing engineering, recognizes contributions of other cultures historically. This redefines the epistemology of science or what counts as science, which, in turn, defines or determines school science curriculum.

Second, from a pedagogical perspective, engineering has potential to be inclusive of students who have traditionally been marginalized in the science classroom and do not see relevance of science or engineering to their lives or future. Through solving problems in home and local contexts (e.g., gardening, improving air quality, or cleaning water pollution in the community), students gain knowledge and understanding of science content, view science as relevant to their lives or future, and engage in science in socially relevant and transformative ways (Rodriguez & Berryman, 2002).

Finally, from a global perspective, engineering offers opportunities for innovation and creativity at the K-12 level. Engineering is a field that is critical to innovation, and exposure to engineering activities (e.g., robotics and invention competitions) can spark interest in the study of STEM or future careers (NSF, 2010). Exposure to engineering at the pre-collegiate level is currently rare (Katehi, Pearson, & Feder, 2009) and NGSS changes that exposure to necessity. This opportunity is particularly important for students who traditionally have not recognized science as relevant to their lives or future as described above and for students who come from multiple languages and cultures in this global community.

Focus on Practices

The ways we describe student engagement in science have evolved over time. Terms such as "hands-on" and "minds-on" have traditionally been used to describe student engagement. Formerly, *National Science Education Standards* (National Research Council [NRC], 1996, 2000) highlighted "scientific inquiry" as the core of science teaching and learning through which students "develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (p. 23). In NGSS, "inquiry-based science" is refined and deepened by the explicit definition of the set of eight scientific and engineering practices, which have major implications for non-dominant student groups (for details, see Lee, Quinn, & Valdés, in press; Quinn, Lee, & Valdés, 2012).

Engagement in any of the scientific and engineering practices involves both scientific sense-making and language use. Students engage in these practices for the scientific sense-making process, as they transition from their inexperienced conceptions of the world to more scientifically-based conceptions. Engagement in these practices is also language intensive and requires students to participate in classroom science discourse. Students must read, write, and visually represent as they develop their models and explanations. They speak and listen as they present their ideas or engage in reasoned argumentation with others to refine their ideas and reach shared conclusions.

These practices offer rich opportunities and demands for language learning at the same time as they support science learning for all students, especially English language learners, students with disabilities that involve language processing, students with limited literacy development, and students who are speakers of social or regional varieties of English that are generally referred to as "non-Standard English". When supported appropriately, the students are capable of learning science through their emerging language and comprehending and carrying out sophisticated language functions (e.g., arguing from evidence, providing explanations, developing models) using less-than-perfect English. By engaging in such practices, moreover, students grow in both their understanding of science and their language proficiency (i.e., capacity to do more with language).

Crosscutting Concepts

Crosscutting concepts are overarching scientific themes that emerge across all scientific disciplines. These themes provide the context for new disciplinary core ideas and enable students to "develop a cumulative, coherent, and usable understanding of science and engineering" (NRC, 2011, p. 4-1). Thus, crosscutting concepts bridge the engineering, physical, life, and Earth/space sciences, and offer increased rigor across science disciplines over K-12. Although *Science for All Americans* (AAAS, 1989) identified "common themes" and *National Science Education Standards* (NRC 1996) identified "unifying concepts and processes," NGSS brings crosscutting concepts to the forefront as one of three dimensions of science learning.

Crosscutting concepts offer frameworks to conceptualize disciplinary core ideas. In this way, students think of science learning not as memorization of loosely connected facts, but as integrated and interrelated concepts. This is a fundamental understanding of science that is often implied as background knowledge for students in "gifted," "honors," or "advanced" programs. Through NGSS, explicit teaching of crosscutting concepts enables less privileged students, most of whom from non-dominant groups, to make connections among big ideas that cut across science disciplines. This could result in leveling the playing field for students who otherwise might not have exposure to such opportunities.

NGSS Connections to CCSS for English Language Arts and Mathematics

NGSS makes connections across school curriculum. For example, students understand the crosscutting concept of patterns not only across science disciplines but also across other subject areas of language arts, mathematics, social studies, etc. Likewise, the crosscutting concept of cause and effect can be used to explain phenomena in Earth science as well as to examine character or plot development in literature, which can be related to CCSS in English language arts.

The norms for classroom discourse are to a great extent common across all the science disciplines and indeed across all the subject areas. The convergence of disciplinary practices across CCSS for English language arts and literacy, CCSS for mathematics, and NGSS are highlighted in Figure 1. For example, students are expected to engage in argumentation from evidence; construct explanations; obtain, synthesize, evaluate, and communicate information; and build a knowledge base through content rich texts across the three subject areas. Such convergence is particularly beneficial for students from non-dominant groups who are pressed for instructional time to develop literacy and numeracy at the cost of other subjects, including science.

Integration of subject areas is an avenue that strengthens science learning for all students, particularly for students who have traditionally been underserved. In the current climate of accountability policies dominated by reading and mathematics, science tends to be de-emphasized due to the perceived urgency of developing basic literacy and numeracy for students in low-performing schools including, but not limited to, English language learners and students with limited literacy development. Thus, allocation and utilization of instructional time across subject areas will benefit these students. Furthermore, the convergence of core ideas, practices, and crosscutting concepts across subject areas offers multiple entry points to build and deepen understanding for these students.

Initiatives are emerging to identify language demands and opportunities as English language learners engage in NGSS as well as CCSS for English language arts and for mathematics. For example, the Understanding Language Initiative <ell.stanford.edu> is aimed at heightening educator awareness of the critical role that language plays in CCSS and NGSS. Its long-term goal is to help educators understand that the new standards cannot be achieved without providing specific attention to the language demands inherent to each subject area. This initiative seeks to improve academic outcomes for English language learners by drawing attention to critical aspects of instructional practices and by advocating for necessary policy supports at the state and local levels.

Implementation of Effective Strategies

To make NGSS accessible to all students, implementation of effective strategies should capitalize on learning opportunities while being aware of demands that NGSS presents to non-dominant student groups, as described in the previous section. Unfortunately, existing research literature does not address students' performance expectations as envisioned in NGSS based on the mastery of scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Furthermore, the existing research literature treats non-dominant student groups separately; For example, research on race or ethnicity, research on English language learners, research on students with disabilities, and research on gender exists as distinct research traditions (for effective strategies for non-dominant groups in science classrooms, see Special issue on diversity and equity in science education, in press; for discussion of classroom strategies and policy issues, see Lee & Buxton, 2010).

Despite such distinct research areas, there seem to be common themes that tie these research areas together. In describing "equitable learning opportunities" for non-dominant student groups, Lee and Buxton (2010) highlight the following features: (1) value and respect the experiences that all students bring from their backgrounds (e.g., homes or communities), (2) articulate students' background knowledge (e.g., cultural or linguistic knowledge) with disciplinary knowledge, and (3) offer sufficient school resources to support student learning.

First, to value and respect the experiences that all students bring from their backgrounds, it is important to make diversity visible. In the process of making diversity visible, there are both connections and disconnections between home/community and classroom/school. Effective teachers understand how disconnections may vary among different student groups, as well as how to capitalize on connections. Effective classroom strategies build on the knowledge of such connections or disconnections between students' background knowledge and experiences, on the one hand, and scientific knowledge and practices, on the other hand.

Second, to articulate students' background knowledge with disciplinary knowledge of science, it is important to capitalize on "funds of knowledge" (González, Moll, & Amanti, 2005). Social and intellectual resources contained in families and communities can serve as resources for academic learning. Effective teachers ask questions that elicit students' funds of knowledge related to science topics. They also use cultural artifacts and community resources in ways that are academically meaningful and culturally relevant.

Finally, school resources constitute essential elements of a school's organizational context for teaching and learning. School resources to support student learning involve material resources, human resources (or capital), and social resources (or capital). School resources are likely to have a greater impact on the learning opportunities of non-dominant students who have traditionally been underserved in science education. In schools and classrooms where non-dominant students reside, resources are often scarce, forcing allocations of the limited resources for some areas (e.g., reading and mathematics) and not others (e.g., science and other non-tested subject areas).

Each of these features in relation to NGSS for non-dominant student groups is described in more detail below.

Effective Classroom Strategies

Key features of effective classroom strategies from the research literature on each of non-dominant groups are summarized below. In recognition of the fact that each area of research literature has been developing as an independent body of knowledge, the description of strategies is provided for each group. Yet, it is noted that while some strategies are unique to a particular group (e.g., home language use with English language learners, accommodations or modifications for students with disabilities), other strategies apply to all students broadly (e.g., multiple modes of representation). More detailed descriptions are provided in each of the seven case studies, including the four accountability groups defined in NCLB and three additional groups. While effective science instruction of NGSS will be based on the existing research literature, NGSS will also stimulate new directions for research to actualize its vision for all students.

Economically disadvantaged students. Strategies to support economically disadvantaged students include: (1) keeping high expectations of science learning and achievement, (2) creating print-rich instructional environments, (3) implementing project-based learning as a form of connected science, and (4) building significant relationships using active positionality.

Students from major racial and ethnic groups. Effective strategies for students from major racial and ethnic groups fall into the following categories: (1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representation and multimodal experiences, and (4) school support systems including role models and mentors of similar racial or ethnic and gender backgrounds.

Students with disabilities. Students with disabilities have an Individual Education Plan (IEP) that mandates the accommodations and modifications that teachers must provide to them to support their learning in the regular education classroom. Accommodations allow students to overcome or work around their disability with the same performance expectations of their peers, whereas modifications generally change the curriculum or lower the performance expectations for a specific student. Accommodations are made in the following general areas: (1) scheduling or time demands, (2) setting or environment, (3) instructional materials, (4) instructional methods, and (5) student response options for assignments and assessments. Modifications may include alternate (1) curriculum goals and/or expectations, (2) assessments, or (3) course requirements.

Students with limited English proficiency. The research literature indicates five areas where teachers can support both science and language learning for English language learners: (1) strategies for literacy development (reading and writing), (2) language support strategies typically identified as English for Speakers of Other Languages (ESOL) strategies, (3) discourse strategies to facilitate English language learners' participation in classroom discussion, (4) home language support, and (5) home culture connections.

Gender. The research literature points to three main areas where schools can positively impact girls' achievement, confidence and affinity with science and engineering: (1) instructional strategies to increase girls' science scores and their intentions to continue on in science (e.g., purposeful pairing; real-world, meaningful connections to science); (2) curricula that enhance girls' achievement and raise their confidence in science by promoting images of successful females in science, and (3) classrooms' and schools' organizational structure in ways that benefit girls in science (e.g., after school activities that target girls, recruiting girls for advanced classes).

Students in alternative education programs. Recent research correlates specific risk factors to the likelihood of students dropping out of school in multiple domains: student, family, school, and community. Consistent with these risk factors, five strategies have been identified to have a positive impact for students in alternative education: (1) after-school opportunities and informal education, (2) active learning, (3) career and technology education, (4) safe learning environment, and (5) individualized instruction.

Gifted and talented students. Gifted and talented students may have such characteristics as intense interests, rapid learning, motivation and commitment, curiosity, and questioning skills. Based on the research literature, teachers can employ effective differentiation strategies to promote science learning of gifted and talented students in these domains: (1) fast pacing, (2) level of challenge (including differentiation of content), (3) opportunities for self-direction, and (4) strategic grouping.

Home and Community Connections to School Science

While it has long been recognized that building home-school connections is important for the academic success of non-dominant student groups, in practice, this is rarely done in an effective manner. Tensions may exist as parents and families desire to maintain in their children the cultural and linguistic practices of their heritage while also wanting their children to participate fully in the dominant school culture. A challenge facing schools is the perceived disconnect between school science practices and home and community practices of non-dominant student groups. Traditionally, research on home-school connections looked at how the family and home environments of non-dominant student groups measured up to the expectations and practices of the dominant group. The results were interpreted in terms of deficits in students' family and home environments, as compared to their dominant counterparts. In contrast, more recent research identifies resources and strengths in the family and home environments of non-dominant student groups (Calabrese Barton et al., 2004). Students bring to the science classroom funds of knowledge from their homes and communities that can serve as resources for academic learning if teachers understand and find ways to activate this prior knowledge (González, Moll,

& Amanti, 2005). Science learning is built upon tasks and activities that occur in the social contexts of day-to-day living, whether or not the school chooses to recognize this.

Several approaches build connections between home/community and school science; Some aim to increase parent involvement in their children's science classroom by encouraging parents' roles as partners in science learning. Others engage students in defining problems and designing solutions of community projects in their neighborhoods (typically engineering). Through NGSS, students can engage scientific and engineering practices, crosscutting themes, and disciplinary core ideas by connecting school science to their out-of-school experiences in home and community contexts.

Parent involvement in school science. Concerted efforts should be made to support and encourage parent involvement to promote positive engagement and achievement of non-dominant student groups in science classrooms. Parents without academic background in science can be partners in their children's science education by setting high expectations for academic success and higher education. Teachers can form partnerships with parents, facilitating dialogue with parents to solicit their help with homework and their attendance at science-related events in the school. Siblings and peers can also serve as positive role models on academic achievement.

To promote parents' agency in their involvement in school science, schools can play a part to address their needs from the school and remove roadblocks to participation. Schools may need to individually invite underserved families on science related field trips, making certain that particular concerns are met (e.g., child care, translation, transportation) so that the parents are able to attend. Teachers can conscientiously create homework assignments that invite joint participation of the child and parent to complete a task together (e.g., observe the phases of the moon, record water use in the house). A non-evaluative survey related to science content can generate classroom discussions that bridge home and school. Homework assignments encourage dialogue, increase interest among both parents and students, and solicit home language support for science learning.

Parents from non-dominant backgrounds feel comfortable with the school when they perceive the school as reflecting their values, and such parents, in turn, are most likely to partner with the school. For example, a science camp focused on African American achievement had high parental participation because its goals highlighted issues related to African American identity and culture (Simpson & Parsons, 2008). Teachers can also increase parent involvement by relating after school and summer school themes around values that are important to the families and communities.

Student engagement with school science in community contexts. Strategies that incorporate the community, underscore the importance of connecting the school science curriculum to the students' everyday lives and the realities of the community in which they live. It is through these connections that students who have traditionally not been part of science recognize science as relevant to their lives and future, deepen their understanding of science concepts, develop agency in science, and consider careers in science.

Student involvement in learning science in a community context may take different approaches. First, both disciplinary and informal education experts underscore the importance of drawing a connection between science and the neighborhood that the students reside in. Teachers develop a connection between the students' experiences and the science they study in school by incorporating the neighborhood and community in the science curriculum. Effective approaches can include engaging in outdoor exploration (e.g., birds surveys, weather journals) and analyzing local natural resources (e.g., land forms in the neighborhood, soil composition).

Second, the community context for science education capitalizes on the community resources and funds of knowledge to make science more culturally, linguistically, and socially relevant for diverse student groups (González, Moll, & Amanti, 2005). For example, a teacher could tap into the community as a resource by recruiting a community member to assist an upper elementary class, as students investigate the pollution along a river near the school. By bringing the neighborhood and community into the science classroom, students learn that science is not only applicable to events in the classroom, but it also extends to what they experience in their homes and to what they observe in their communities.

Finally, "place-based" science education is consistent with culturally relevant pedagogy (Ladson-Billings, 1995). Through social activism, students develop critical consciousness of social inequities, especially as such inequities exist in their communities. When youth find science education to be empowering and transformative, they are likely to embrace and further investigate what they are learning, instead of being resistant to learning science. Thus, school science should be reconceptualized to give a more central role to students' lived experiences and identities.

Context

To engage all students in learning NGSS, it is important to understand the context that influences science learning by diverse student groups. This section briefly describes student demographics, science achievement, and educational policies affecting non-dominant student groups. More details are presented in each of the seven case studies in terms of economically disadvantaged students, racial or ethnic minority students, students with disabilities, English language learners, female students, students in alternative education programs, and gifted and talented students.

Student Demographics

The student population in the U.S. is increasingly more diverse:

- **Economically disadvantaged students.** According to the American Community Survey report from the 2010 U.S. Census Bureau minorities (U.S. Census Bureau, 2012), the nation is experiencing the highest poverty rate at 22% since the poverty survey began in 2001. In 2009-10, approximately 25% of students were in high poverty schools (National Center for Education Statistics [NCES], 2012). The percentage of high poverty schools increased from 12% in 1999 to 20% in 2010. High poverty schools are concentrated in the cities compared to the town and rural areas.

- **Students from major racial or ethnic minority groups.** The student population in the U.S. is increasingly more diverse racially and ethnically. According to the 2010 U.S. Census data, 36% of the U.S. population is racial minorities (U.S. Census Bureau, 2012). Among the school-age population under 19 years old, 45% are minorities. It is projected that the year 2022 will be the turning point when racial minorities collectively will become the majority in terms of percentage of the school-age population.

- **Students with disabilities.** The number of children and youth ages 3-21 receiving special education services under the Individuals with Disabilities Education Act (IDEA) rose from 4.1 million to 6.7 million between 1980 and 2005, or from 10% to 14% of the student enrollment (NCES, 2011). That number decreased to 6.5 million or 13% of student enrollment by 2009.

- **Students with limited English proficiency.** More than 20% of school age children speak a language other than English at home, and limited English Proficient (LEP) students (the federal term) have more than doubled from 5% in 1993 to 11% in 2007 (NCES, 2011). The 11% of LEP students does not count those who were classified as LEP when younger but who are now considered proficient in English or during a monitoring period.

- **Students in alternative education programs.** According to the Alliance of Excellent Education, "Every year, approximately, 1.2 million students do not graduate on time." This number equates to 7,000 students per day. Since 2009, states have made progress to mitigate the crisis. Nevertheless, it is estimated that 2.1 million students still attend dropout "factories" (Balfanz, 2012).

- **Gifted and talented students.** Reporting the demographics for gifted and talented students is difficult due to wide inconsistencies in the definition, assessments to identify them, and funding for gifted and talented programs across the nation. The National Association for Gifted Children (NAGC, 2012) defines giftedness as "those who demonstrate outstanding levels of aptitude or competence in one or more domains" and estimates that this definition describes approximately three million, or roughly 6% of all students, K-12.

Several caveats are made with regard to student diversity. First, each demographic subgroup is not a homogenous or monolithic group, and there is a great deal of variability among members of the group. For example, categories of disabilities include: specific learning disabilities, speech and language impairments, other health impairments, intellectual disability, emotional disturbance, developmental delay, autism, multiple disabilities, hearing impairment, visual impairment, orthopedic impairment, deaf-blindness, and traumatic brain injury. These categories could be classified as cognitive, emotional, and physical disabilities. Similarly, English language learners vary in terms of levels of proficiency in English, literacy in home language, schooling in home country, immigration status, parents' education, etc. Such variability among members of a group cautions the danger of essentializing.

Second, there is a significant overlap among non-dominant student groups. For example, most English language learners are racial or ethnic minorities. In addition, 60% of economically disadvantaged students, including large proportions of racial or ethnic minorities and English language learners, live the cities (NCES, 2012). As a result, these students face multiple challenges in achieving academic success.

Finally, specific student groups are either overrepresented or underrepresented in education programs. For example, females are underrepresented in engineering and physics (National Science Foundation [NSF], 2012). Racial or ethnic minority students, economically disadvantaged students, and English language learners are underrepresented in gifted and talented programs, whereas they are overrepresented in special education programs (Harry & Klingner, 2006).

Science Achievement

While the student population in the U.S. is becoming more diverse, science achievement gaps persist by demographic subgroups. The results of international and national science assessments indicate the need for a two-pronged approach to enhancing student science outcomes. Achievement gaps must be closed among demographic subgroups of students, while improved science outcomes should be promoted for all students. In the 2010 report, "Preparing the next generation of STEM innovators," the National Science Board states, "In America, it should be possible, even essential, to elevate the achievement of low-performing at-risk groups while simultaneously lifting the ceiling of achievement for our future innovators" (NSF, 2010).

U.S. students have not ranked favorably on international comparisons of science achievement as measured by Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA). Although TIMSS science results for U.S. 4th and 8th graders showed positive trends since its first administration in 1995 through the latest administration in 2007, PISA results for 15 year olds did not corroborate trends indicated by TIMSS. When it comes to applying science in meaningful ways (e.g., using scientific evidence, identifying scientific issues, and explaining phenomena scientifically) as measured by PISA, U.S. students performed in the bottom half of the international comparison and did not show significant improvements since its first administration in 2000 through its latest administration in 2009.

At the national level, National Assessment of Educational Progress (NAEP) provides U.S. students' science performance over time. Focusing only on more recent NAEP science assessments in 1996, 2000, 2005, 2009, and 2011, achievement gaps persist among demographic subgroups of students across grades 4, 8, and 12. Results are reported by family income level (based on eligibility for the National School Lunch Program), race or ethnicity, students with disabilities, English language learners, gender, and type of school (public or private). It is noted that these subgroups represent the accountability groups defined in NCLB.

The framework for NAEP science involves science content in three areas (physical science, life science, and Earth and space sciences) and four science practices to measure what students are able to do with the science content (identifying science principles, using science principles, using scientific inquiry, and using technological design). Two other developments are noteworthy in relation to NGSS. First, the 2009 NAEP science included interactive computer and hands-on tasks to measure how well students were able to reason through complex problems and apply science to real-life situations. This approach could pave a way for assessment of scientific and engineering practices in NGSS. Second, the first-ever NAEP Technology and Engineering Literacy Assessment (TELA) is currently under development. The initial assessment, planned for 2014, will be a probe—a smaller-scale, focused assessment on a timely topic that explores a particular question or issue. This approach could be used for assessment of engineering in NGSS.

A clear understanding of science achievement gaps should take into account certain methodological limitations in how these gaps are measured and reported. Science achievement is typically measured by standardized tests administered to national and international student samples. A strength of these measures is that they provide access to large data sets that allow for the use of powerful statistical analyses. However, these measures also present limitations.

First, standardized tests provide only a general picture of how demographic variables relate to science achievement. For example, "Hispanic" is likely to be treated as a single category of race or ethnicity, masking potentially important differences in performance among Mexican-Americans, Puerto Ricans, and Cubans. Similarly, the group of students with disabilities (SD) is generic, referring to students who usually have an Individualized Education Program (IEP) and could include both learning disabled (LD) or emotionally disturbed (ED). Thus, achievement data are generally lumped together for very different disabilities. Such overgeneralization hinders more nuanced understanding of achievement gaps, thereby limiting the potential effectiveness of educational interventions aimed at reducing these gaps.

Second, standardized tests have the potential to reinforce stereotypes, both positive and negative, of certain demographic groups (Rodriguez, 1998). For example, the "model minority" stereotype of Asian American students as strong performers in mathematics and science may well be supported by generalized test data for the racial category of Asian American. However, such a result masks great disparities within this group, such as for Southeast Asian refugees with limited literacy development in their homes or communities. These students are less likely to have their needs met in equitable ways if teachers presume that they learn science and mathematics with little trouble. In reverse, high-achieving Hispanic or African American students may be disadvantaged by teachers or counselors who underestimate them and set low expectations of their academic success.

Finally, standardized tests do not analyze or report interactions between variables. For example, as racial/ethnic minority students are disproportionately represented in free or reduced price lunch programs, science achievement gaps between race/ethnicity and socioeconomic status are conflated, as are science achievement gaps by race/ethnicity and gender.

Educational Policies

The passing of the NCLB Act of 2001 (the reauthorized Elementary and Secondary Education Act [ESEA]) ushered in a new era of high-stakes testing and accountability policies. Districts and schools are accountable for making an adequate level of achievement gain each year, referred to as annual yearly progress (AYP). The theory behind NCLB assumes that states, districts, and schools will allocate resources to best facilitate the attainment of AYP. Decisions concerning resources and practices are determined largely by test scores on state assessments.

Although NCLB is most often associated with accountability systems, there is a second property of NCLB that has also been a focus of attention. NCLB mandates that each state report AYP disaggregated for demographic subgroups of students. Mandating this disaggregated reporting of AYP results in potentially desirable outcomes: (a) each of the groups is publicly monitored to examine achievement and progress; (b) resources are allocated differentially to these groups to enhance the likelihood that they meet AYP; and (c) if AYP is not met for these groups in schools receiving Title I funding, students are provided with additional academic assistance through Supplemental Educational Services (e.g., tutoring) and the right to transfer to another public school. Schools, districts, and states cannot hide historically underperforming demographic groups, since NCLB forces the state to publicly monitor these groups and to be accountable for their performance. On the undesirable side, however, all of the added attention to high-stakes testing does not necessarily result in improved teaching. In fact, the increased emphasis on testing could detract from academically rigorous learning opportunities that are often lacking with students from certain demographic subgroups. Similarly, calling more public attention to the failures of schools to adequately meet the needs of these students does little to ensure that they will receive instruction that is more engaging, more intellectually challenging, or more culturally or socially relevant.

Although NCLB mandates reporting of AYP for reading and mathematics, the same is not true for science. With respect to science, NCLB required that by the 2007-2008 school year each state would have in place science assessments to be administered and reported for formative purposes at least once during grades 3-5, grades 6-9, and grades 10-12. However, it was up to each state to decide whether to include high-stakes science testing in state accountability systems or AYP reporting. Although science accountability policies affect all students, the impact is far greater for student groups that have traditionally been underserved in the education system.

While the NCLB Act (the reauthorized ESEA) has been in place since 2002, other educational policies are being initiated, including states' requests for federal waivers from NCLB mandates in exchange for designing and implementing their own accountability systems, the Race to the Top program, CCSS for English language arts and literacy and for mathematics, and the anticipated new wave of assessments for CCSS by two comprehensive assessment consortia including Partnership for Assessment of Readiness for College and Careers (PARCC) and Smarter Balanced Assessment Consortium (Smarter Balanced). These initiatives will add still more variability to how science is included in accountability systems and how such systems, in turn, will affect science education for non-dominant student groups.

Separate from federal and state policies that apply to all students, specific policies apply to specific student groups. According to the NCLB Act:

- Title I is the largest federally funded educational program intended for "improving the academic achievement of the disadvantaged" in order to meet "the educational needs of low-achieving children in our Nation's highest-poverty schools, limited English proficient children, migratory children, children with disabilities, Indian children, neglected or delinquent children, and young children in need of reading assistance."

- Title I, Part H, states that the Dropout Prevention Act aims "to provide for school dropout prevention and reentry and to raise academic achievement levels by providing grants that (1) challenge all children to attain their highest academic potential; and (2) ensure that all students have substantial and ongoing opportunities to attain their highest academic potential through schoolwide programs proven effective in school dropout prevention and reentry."

- Title III addresses "language instruction for limited English proficient and immigrant students."

- Title VII is designed for "Indian, Native Hawaiian, and Alaska Native education".

- Title IX prevents gender-based discrimination within federally funded educational programs. Title IX states, "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving federal financial assistance" (Public Law No. 92-318, 86 Stat. 235).

- Title IX, Part A, SEC. 9101 (22), provides a federal definition and federal research funding for gifted and talented students – "The term gifted and talented, when used with respect to students, children, or youth, means students, children, or youth who give evidence of high achievement capability in areas such as intellectual, creative, artistic, or leadership capacity, or in specific academic fields, and who need services or activities not ordinarily provided by the school in order to fully develop those capabilities".

- The Individuals with Disabilities Education Act (IDEA) is a law ensuring services to children with disabilities.

Conclusions and Implications

NGSS offers a vision of science teaching and learning that presents both learning opportunities and demands for all students, particularly student groups that have traditionally been underrepresented in the science classroom. Furthermore, NGSS is connected to CCSS that are beginning to be adopted and implemented in most of the states in the U.S. Changes in the new standards occur as student demographics in the nation are becoming more diverse while science achievement gaps persist among demographic subgroups.

The academic rigor and expectations of NGSS are less familiar to many science teachers than typical teaching practices and require shifts for science teaching which are consistent with shifts for teaching CCSS for English language arts and mathematics (see Figure 1). Science teachers need effective strategies to include all students regardless of racial, ethnic, cultural, linguistic, socioeconomic, and gender backgrounds. While effective classroom strategies to enable students to engage in NGSS will draw from the existing research literature, NGSS will also stimulate new research agenda. Future research agenda will identify ways to make connections between home/community and school science, on the one hand, and to utilize and allocate school resources to support student learning in terms of material resources, human capital, and social capital, on the other hand.

Effective implementation of NGSS with all students, including non-dominant student groups, will require shifts in the education support system. Key components of the support system include teacher preparation and professional development, principal support and leadership, public-private-community partnerships, formal and informal classroom experiences that require considerable coordination among community stakeholders, technological capabilities, network infrastructure, cyber-learning opportunities, access to digital resources, online learning communities, and virtual laboratories. As NGSS implementation takes roots over time, these components of the education system will also evolve and change accordingly.

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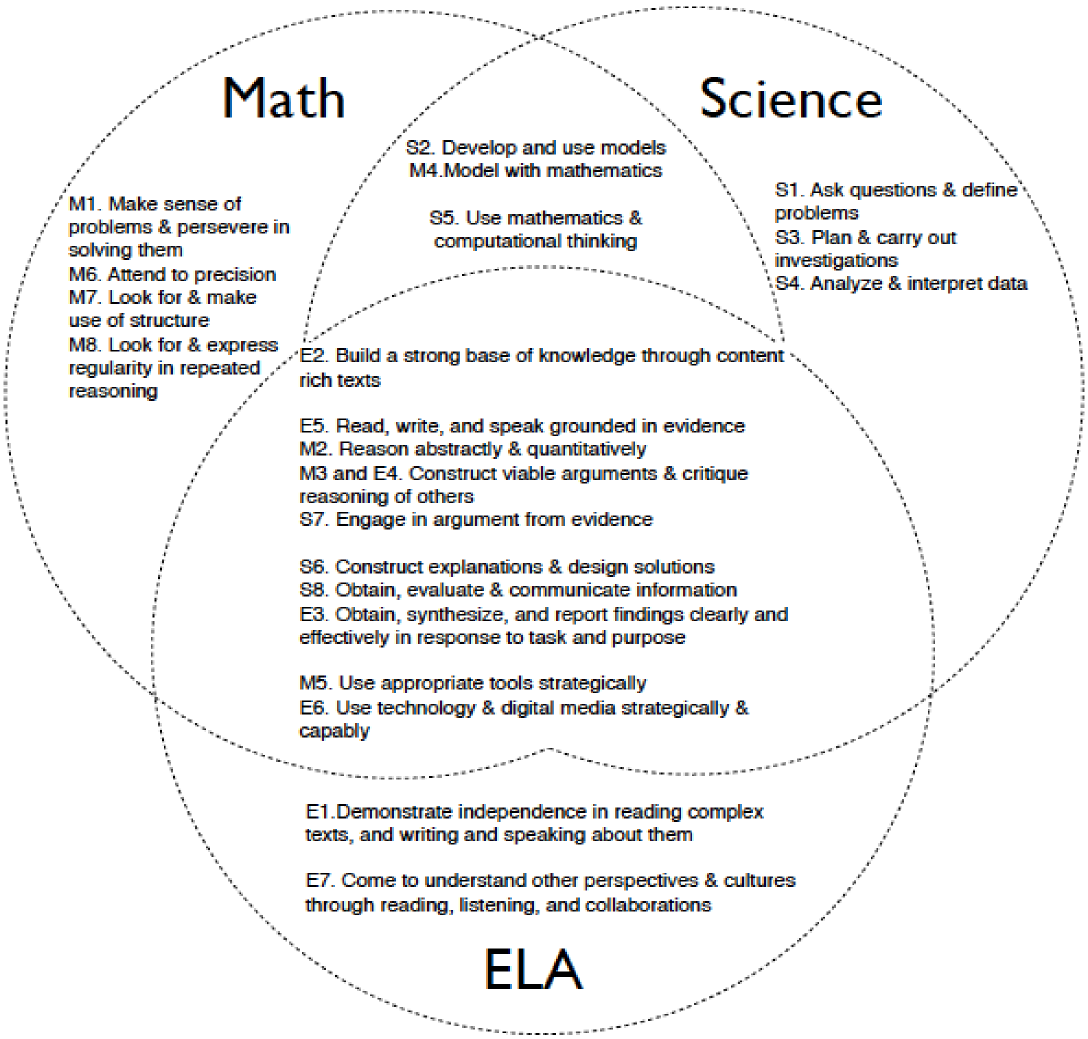

Figure 1. *Relationships and convergences found in the Common Core State Standards for Mathematics (practices), Common Core State Standards for English Language Arts and Literacy (student portraits), and the Science Framework (science & engineering practices)*

Note: The letter and number set preceding each phrase denotes the discipline and number designated by the content standards. The Science Framework is being used to guide the development of the Next Generation Science Standards.

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