Appendix E

Summary

English learners (ELs) bring a wealth of resources to science, technology, engineering, and mathematics (STEM) learning, including knowledge and interest in STEM-related content that is born out of their experiences in their homes and communities, home languages, variation in discourse practices, and, in some cases, experiences with schooling in other countries. ELs are those students ages 3 through 21, enrolled in an elementary or secondary school, not born in the United States or whose native language is a language other than English, and whose proficiency in speaking, reading, writing, or understanding the English language may be sufficient to deny the individual the ability to successfully achieve in classrooms where the language of instruction is English. The diversity of ELs includes heterogeneity in cultures, languages, and experiences that may have an impact on these students' education (including the contexts that expose them to risk factors that may have negative impacts). Federal, state, and local policies can either facilitate ELs' opportunities in STEM or constrain teaching and learning in ways that are detrimental. This report addresses the factors that affect ELs' access and opportunity to rigorous, grade-appropriate STEM learning.

The National Science Foundation commissioned the National Academies of Sciences, Engineering, and Medicine to examine the research on ELs' learning, teaching, and assessment in STEM subjects, including the role of language in learning STEM, successful programs for ELs or interventions both within the United States and abroad, and the learning needs of preservice and in-service STEM teachers with respect to ELs in PreK–12. The committee was asked to consider the complex social and academic

use of language delineated in the new mathematics and science standards, the diversity of the population of ELs, and the integration of English as a second language instruction with core instructional programs in STEM. The committee was also asked to consider all children and youth who are learning and speaking a language other than English at home (often referred to as dual- or multi-language learners) and give particular attention to students who have limited English skills and may have been formally identified as such by the school or district.[1] What follows are some core findings discussed within the different chapters of the report.

CORE FINDINGS

Educational Context

Inconsistencies in the classification of ELs is an undercurrent that has substantial implications for understanding ELs' performance in STEM, given that it affects everything from policy to research to instruction. The practice of excluding recently English-proficient ELs from the EL accountability group leads to overestimation of academic achievement gaps in STEM between ELs and non-ELs, and consequently to misperceptions of ELs' STEM proficiency and ineffective policy responses. Moreover, some schools operate under the incorrect assumption that English proficiency is a prerequisite to meaningfully engage with STEM learning. However, the research suggests that a shift is needed by recognizing the assets that ELs bring to the classroom and understanding that some deficits in student performance arise from lack of access and not from limited ability, language proficiency, or cultural differences.

STEM Learning and English Language Development

ELs develop STEM knowledge and language proficiency when they are engaged in meaningful interaction in the classroom that includes participation in the kinds of activities in which STEM experts and professionals regularly engage. Whereas there is no language without content, there is some content that is less dependent on language. STEM subjects afford opportunities for alternate routes to knowledge acquisition (i.e., experimentation, demonstration of phenomena, and demonstration of practices) through which students can gain a sense of STEM content without resorting predominantly to language to access meaning—it is through this experience that language is also learned. The committee acknowledges that just as language develops, students develop increasingly sophisticated understandings

[1]The full statement of task appears in Box 1-1 in Chapter 1.

of core disciplinary ideas; as such, engaging ELs early in their education when their peers are also gaining exposure to STEM content is important.

Effective Instructional Strategies and Teacher Education

A review of the evidence on instructional strategies suggests that teachers of ELs who effectively engage with these students are more likely to understand that language is learned through meaningful and active engagement by ELs with language in the context of authentic STEM activities and practices. They encourage ELs to draw on their full range of linguistic and communicative competencies and resources while guiding them toward a focus on STEM meaning-making. Effective teachers of ELs also engage in experiences that foster self-reflection about their assumptions regarding diverse students' and families' engagement with STEM and STEM education. However, although the committee identified many instructional strategies that show great promise for ELs in building disciplinary content knowledge, access to practices, and language proficiency, less effective instructional strategies are still used. This may be related in part to the evidence showing that STEM teachers are not adequately prepared to provide robust learning opportunities that foster simultaneous content knowledge and language development in their classrooms.

The Role of Families and Communities

Children are members of families and larger social communities that help to shape their knowledge and interest in school and in STEM. Families and communities are resources that can bolster schools' efforts to engage ELs in STEM learning. Effective family and community engagement models for ELs in STEM recognize and make connections to families' and communities' cultural and linguistic practices as they relate to STEM topics. Such models can help teachers and schools shift to an asset orientation toward ELs' STEM learning, can increase the engagement of families of ELs in other school-based activities, and can improve ELs' motivation in their STEM learning.

Assessment

The committee identified several challenges in EL testing practice and policy to include the fact that language is the means through which tests are administered, limiting the extent to which appropriate generalization can be made about ELs' academic achievement based on test scores alone. With respect to classroom formative and summative assessments, the research is nascent with respect to ELs, limiting the understanding of lin-

guistically diverse groups and classrooms. Overall, it is imperative that ELs be included during large-scale and classroom-level test development and teacher preparation/professional learning to better reflect the heterogeneity of EL populations, leading to fair, valid, and reliable assessment measures.

Building Capacity to Transform STEM Learning

Policies at the federal, state, and local levels can either facilitate ELs' opportunities in STEM or constrain teaching and learning in ways that are detrimental to ELs' access to and success in STEM learning. School districts demonstrating success with teaching ELs in STEM have leaders who attend to system coherence and do so by designing and implementing organizational structures that enable the integration of language and content within and between levels (i.e., state, district, school) and components of the system (e.g., instruction, curriculum, assessment, professional development, policies for categorization of ELs). Integration of STEM learning and English language learning is possible but may require adjustment to the allocation of fiscal and human resources. Some systems that have succeeded in supporting ELs in STEM have demonstrated flexibility in allocating and aligning fiscal and human resources in service of their desired objectives.

RECOMMENDATIONS

Following its analysis of the available information, the committee reached consensus on a set of conclusions and recommendations. The conclusions and recommendations, as well as a research agenda, to identify gaps in the current research are discussed in Chapter 9. The full set of recommendations are included in the summary below.

RECOMMENDATION 1: Evaluate current policies, approaches, and resources that have the potential to negatively affect English learners' (ELs') access to science, technology, engineering, and mathematics (STEM) learning opportunities, including classification and reclassification, course-taking, classroom instruction, program models offered, professional development, staffing, and fiscal resources, etc.

- **Federal agencies should evaluate the ways in which funds are allocated for research and development that would enhance teaching and learning in STEM for ELs, including efforts that foster pipeline and training programs to increase the number of teachers qualified to teach STEM to ELs.**
- **States should evaluate their definition of EL including proper specification of entrance and exit procedures and criteria for districts.**

Districts should examine the policies and procedures that are in place for consistently implementing these state procedures/criteria for classifying/reclassifying ELs.

- **States should evaluate policies associated with the timing of large-scale state assessments and waivers for assessment (i.e., waivers for science assessment), frameworks for teacher certification, and the distribution of financial and human resources.**
- **District leaders and school personnel should examine (a) the program models and placement of ELs in STEM courses with particular attention to grade bands as well as issues associated with overrepresentation of ELs in remedial courses, (b) preparation of STEM teachers with attention to schools with large EL populations, (c) the opportunities for teacher collaboration and professional development, and (d) the distribution of financial and human resources.**
- **Schools should evaluate ELs' success in STEM classes, the quality of STEM classroom instruction and the positioning of ELs in the classroom, the qualifications of teachers hired, the professional development opportunities offered to teachers, and the resources (e.g., time and space) allocated to STEM learning.**

RECOMMENDATION 2: Develop a high-quality framework to identify and remove barriers to English learners' (ELs') participation in rigorous science, technology, engineering, and mathematics (STEM) learning opportunities.

- **District and school leaders should identify and enact norms of shared responsibility for success of ELs in STEM both within the district central office and within schools, developed by teams of district and school leaders associated with STEM and English language development/English as a second language education.**
- **States should take an active role in collecting and sharing resources across schools and districts.**
- **Leaders in states, districts, and schools should continuously evaluate, monitor, and refine policies to ensure that ELs' STEM learning outcomes are comparable to their never-EL peers.**

RECOMMENDATION 3: Equip teachers and teacher candidates with the requisite tools and preparation to effectively engage and positively position English learners (ELs) in science, technology, engineering, and mathematics (STEM) content learning.

- **Preservice teacher education programs should require courses that include learning research-based practices on how to best support ELs in learning STEM subjects.**
- **Preservice teacher education programs and providers of in-service professional development should provide opportunities to engage in field experiences that include ELs in both classroom settings and informal learning environments.**
- **English as a second language teacher education programs and providers of in-service professional development should design programs that include collaboration with teachers of STEM content to support ELs' grade-appropriate content and language learning in STEM.**
- **Teacher educators and professionals involved in pre- and in-service teacher learning should develop resources for teachers, teacher educators, and school and district leaders that illustrate productive, research-based instructional practices for supporting ELs in STEM learning.**
- **Preservice teacher education and teacher credentialing programs should take account of teacher knowledge of large-scale STEM assessment interpretation, classroom summative task design, and formative assessment practices with ELs.**

RECOMMENDATION 4: Develop high-quality science, technology, engineering, and mathematics (STEM) curricular materials and integrate formative assessment into classroom practice to both facilitate and assess English learners' (ELs') progress through the curriculum.

- **Curriculum developers, educators, and EL researchers should work together to develop curricular materials and resources that consider the diversity of ELs' needs as the materials are being developed and throughout the design process.**
- **EL researchers, curriculum developers, assessment professionals, teacher educators, professional learning providers, and teachers should work collaboratively to strengthen teachers' formative assessment skills to improve STEM instruction and promote ELs' learning.**

RECOMMENDATION 5: Encourage and facilitate engagement with stakeholders in English learners' (ELs') local environment to support science, technology, engineering, and mathematics (STEM) learning.

- **Schools and districts should reach out to families and caregivers to help them understand the available instructional programs in**

STEM and the different academic and occupational opportunities related to STEM, including what resources might be available in the community.

- **Schools and districts should collaborate with community organizations and form external partnerships with organizations that focus on informal STEM learning to make an active effort to directly engage ELs and their caregivers in STEM-related learning activities in an effort to understand their EL families' and communities' assets and needs.**

RECOMMENDATION 6: Design comprehensive and cohesive science, technology, engineering, and mathematics (STEM) assessment systems that consider English learners (ELs) and the impact of those assessments on STEM academic achievement for all students.

- **Developers of large-scale STEM assessments need to develop and use population sampling frameworks that better reflect the heterogeneity of EL populations to ensure the proper inclusion of statistically representative samples of ELs in the process of test development according to sociodemographic variables including language proficiency, first language, geographical distribution, and socioeconomic status.**
- **Decision makers, researchers, funding agencies, and professionals in the relevant fields need to develop standards on the numbers and characteristics of students that need to be documented and reported in projects and contracts involving EL STEM assessment.**

RECOMMENDATION 7: Review existing assessment accommodation policies and develop accessibility resources.

- **States, districts, and schools need to review their existing policies regarding the use of accommodations during accountability assessments to ensure that English learners (ELs) are afforded access to those linguistic accommodations that best meet their needs during instruction as well as during assessment.**
- **States, districts, and schools should also examine their implementation of accommodations to ensure that accommodations are implemented with high fidelity for all ELs, take steps to improve implementation when high fidelity is not realized, and improve poor implementation when it is present.**
- **States and districts involved in developing new computer-administered assessments or revising existing computer-administered**

assessments, should develop those assessments to incorporate accessibility resources rather than rely on accommodations.

- **States involved in the development of new science, technology, engineering, and mathematics assessments should apply universal design principles in the initial development and consider ELs from the beginning.**