The National Academies of
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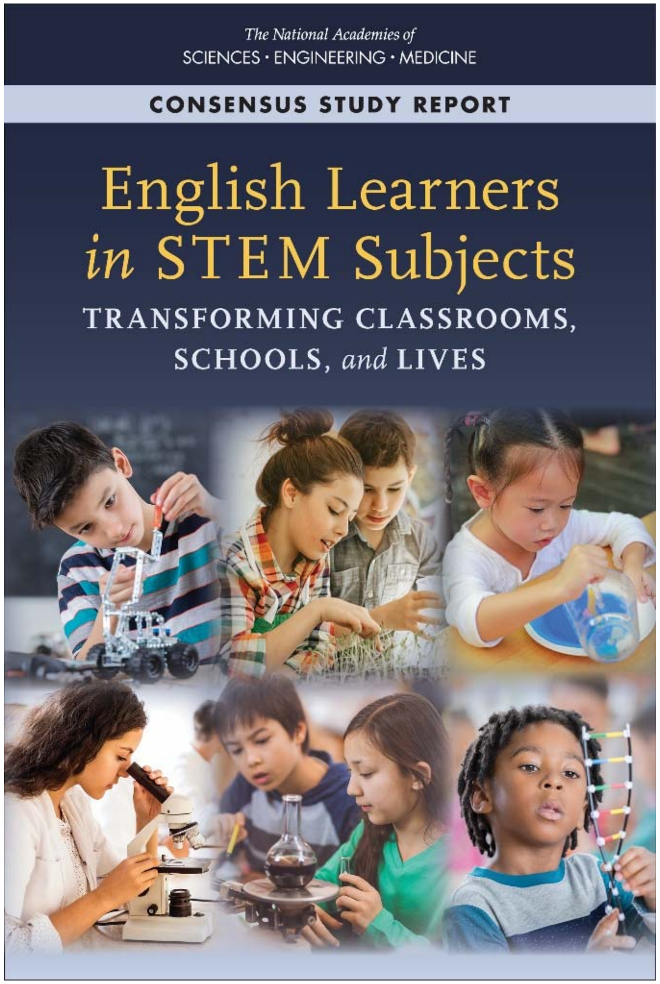
BOARD ON SCIENCE EDUCATION

English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives

Sponsor: National Science Foundation

#ELSTEM

Scope



- ELs pre-K-12th grades
  - Promising approaches to support ELs in learning STEM
  - Role of teachers
  - Assessments in STEM
  - Policies and practices
  - Gaps in current research base

- Role of Families & Communities

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Foundational Points

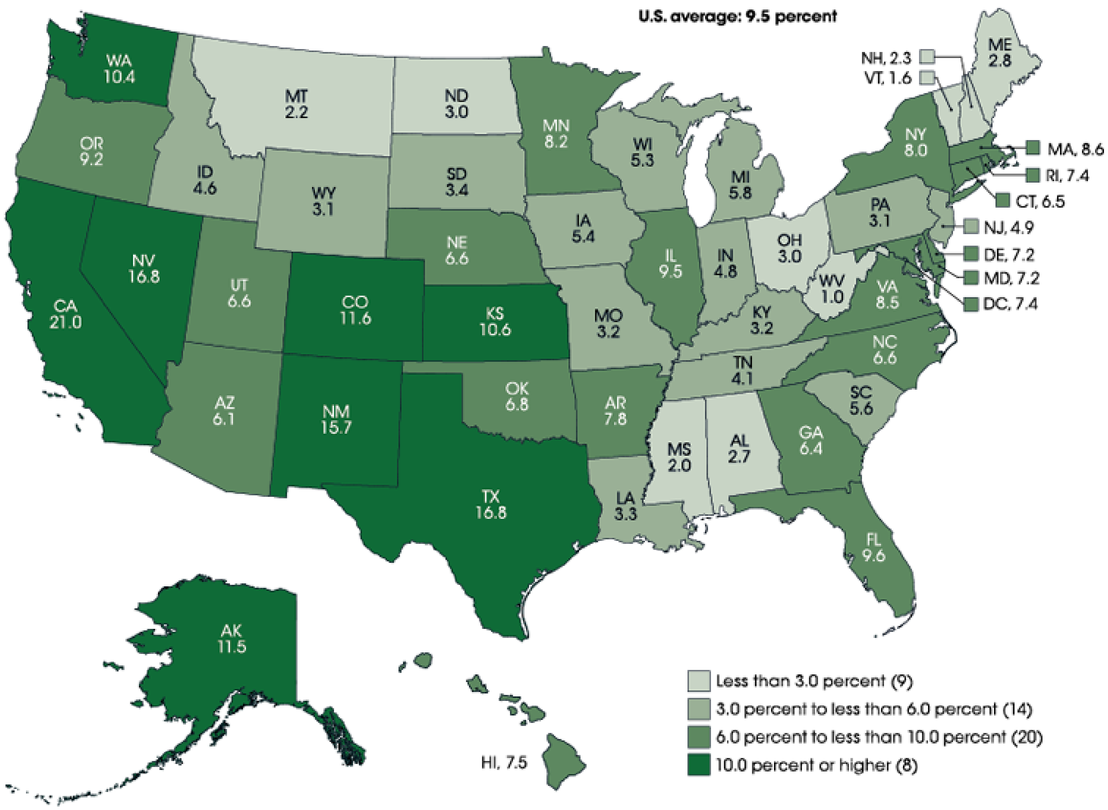
- Inclusion of ELs in STEM is a systemic issue
- Some disciplines still emerging
  - Not enough info on discipline (technology, engineering)
  - Limited info related to ELs
- Research in some areas limited
  - Specific impact of different program models
  - Some areas are more aspirational

Defining ELs

- 9.4% of student population is ELs (4.6 million students)
  - 3–21 years old enrolled in elementary/secondary school
  - Native language not English
  - Proficiency may deny ability to achieve in English-only classrooms
- Long-term ELs
  - Receiving services to develop English proficiency
  - Have not been reclassified after 6 years
  - Plateau in middle/high school → tracking of students
- Newcomers
  - Recently arrived to U.S.
  - Limited research available

Distribution of ELs and Diversity of Home Languages (Data from Fall 2015)

Percentage of public school students who were ELs by state



Number and percentage distribution of ELs by 11 most commonly reported languages

Home Language	Number of ELs	Percentage distribution of ELs
Spanish, Castilian	3,741,066	77.1
Arabic	114,371	2.4
Chinese	101,347	2.1
Vietnamese	81,157	1.7
English	80,333	1.7
Somali	34,813	0.7
Hmong	34,813	0.7
Russian	33,057	0.7
Haitian, Haitian Creole	30,231	0.6
Tagalog	27,277	0.6
Korean	27,268	0.6

SOURCE: U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD) See *Digest of Education Statistics 2017*, table 204.20.

Classification and Reclassification

- Classification & Reclassification of ELs complex
  - Varies across states & even across districts within states
  - No common definition of ELs & agreement on proficiency standards
  - Proficiency in content achievement as criterion for language proficiency is problematic
- Reclassification challenging
  - Too-early: continued support for success needed & w/out may see attrition in long run
  - Too-late: limited access to STEM learning
  - Common practice: exclude recently designated English-proficient ELs from EL accountability group

Conclusion 1: EL Designation

- EL designation is important
- Clear & consistent designations are needed
  - Reduce misperceptions of ELs’ proficiency in STEM academic achievement
  - Enable deeper understanding of
    - academic achievement
    - what program models & instructional strategies work best
    - specific approaches work best for EL subgroups under specific conditions

Conclusion 2: Issues of Access

ELs lack access to STEM learning opportunities

- Limited opportunity to engage with challenging, grade-appropriate science & mathematics content & disciplinary practices.
- Exclusion from rigorous science or mathematics courses, placement in remedial courses, & poor advising regarding course selection.
- Little info about ELs in technology & engineering-based instruction.

High School Course Completion: Mathematics and Science

Highest Mathematics Course Completion

	Bilingual EL Student (N=550)	Bilingual Not in ESL (N=3000)	Native English Speaker (N=16,900)
No Math	4.8%	2.8%	2.4%
Basic Math	1.1%	0.5%	0.5%
Pre-Algebra	1.1%	0.3%	0.3%
Algebra	9.7%	5.2%	4.7%
Geometry	14.5%	9.5%	8.3%
Algebra II	23.6%	17.6%	20.8%
Trigonometry	16.3%	21.6%	24.7%
Beyond Trigonometry	21.2%	19.9%	22.6%
Calculus	2.8%	4.6%	5.6%
Advanced Calculus	4.9%	18.0%	10.1%

- ≈5% ELs have no math compared to 2.4% of native speaking peers
- ≈5% enrolled in advanced courses → less than half of other peers

Science Course Completion

	Bilingual EL Student (N=550)	Bilingual Not in ESL (N=3000)	Native English Speaker (N=16,900)
No Science	0.2%	0.0%	0.0%
Integrated Sciences	32.7%	26.6%	23.7%
Earth Science	63.2%	57.0%	63.8%
Biology	89.6%	93.3%	93.9%
Chemistry	52.0%	72.4%	70.4%
Physics	26.8%	44.5%	36.5%
Any AP, IB, or Honors	11.8%	29.3%	20.1%

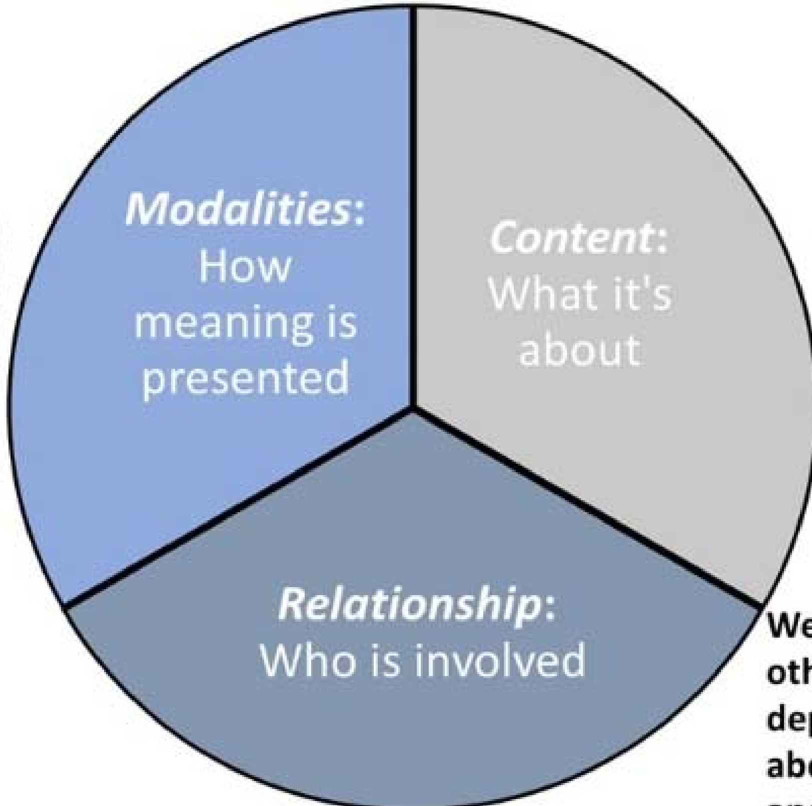
- Science does not have same linear progression as mathematics
- ELs less likely to take science courses overall

Data from HSLS:2009 High School Transcript Study

Register

Meaning-making choices: Content, Relationships, and Modalities

Modalities: Gesture, speech, writing, drawing, graphing, choice of language or language variety



Content: Choices shaped by the topic, process, activity, discipline

We draw on different language and other meaning-making resources depending on what we are interacting about, whom we are interacting with, and the modalities available in a particular context.

Relationships: Shaped by role, status, formality, grouping

Conclusions 3-5: Language and the STEM Disciplines

- Mathematics & Science
  - Disciplinary practices allow ELs to develop disciplinary knowledge while engaging in meaningful language use
  - Developmental in nature leading to sophisticated understandings & capabilities → implications for structuring & implementing instruction in early grades

When ELs have the opportunity to use *all* of their meaning-making resources during STEM instruction, these linguistic resources are essential for STEM learning.

Classroom Culture: Teachers Beliefs, Biases, and Positioning of ELs

- Teachers' attitudes, beliefs, & expectations about ELs' capacity for grade-appropriate STEM learning influence teachers' approaches to & engagement of ELs in STEM instruction.
  - Teachers tend to hold deficit view but asset views promote learning.
  - When teachers have positive expectations more likely to provide meaningful STEM learning opportunities for ELs.
- Teachers play a critical role in positioning ELs as competent members in STEM classrooms.
  - Providing meaningful STEM learning opportunities for ELs can increase teachers' comfort working with diverse students.
  - Teachers that engage with families more likely to have an appreciation for their cultural & linguistic differences.

Conclusion 11: Promising Instructional Strategies

- Engage Students in Disciplinary Practices
- Engage Students in Productive Discourse and Interactions with Others
- Utilize and Encourage Students to Use Multiple Registers and Multiple Modalities
- Leverage Multiple Meaning-Making Resources
- Provide Some Explicit Focus on How Language Functions in the Discipline

Integration of STEM content & language learning can be achieved when teachers of STEM content work with ESL teachers who recognize *functional use of language* in STEM instruction.

Conclusion 12 & 14: Preservice and In-service Teachers

- No adequate preparation to provide *appropriate* STEM-related learning opportunities to ELs
- Few opportunities to learn how to integrate language into STEM learning or how to enhance curricula
- When content teachers & ESL teachers have shared professional development both groups of teachers more likely to learn knowledge & competencies that benefit ELs.

Conclusion 15: Teacher Educators

Few opportunities to learn how to equip preservice teachers to teach STEM to ELs.

- Need professional development with other teacher educators with expertise in supporting preservice teachers learning to work with ELs
- Collaborate with teachers who successfully teach ELs
- Professional development focuses on student thinking in STEM, disciplinary practices and discourse, and curriculum materials that teachers will use in teaching

Recommendation 3: Equip *all* teachers with requisite tools and preparation

Preservice Teacher Education Programs

Require courses that include learning research-based practices for supporting ELs in learning STEM subjects

Preservice Teacher Education Programs/In-service Professional Development Providers

Provide opportunities to engage in field experiences that include ELs in both classroom settings and informal learning environments

ESL Teacher Education Programs/In-service Professional Development Providers

Design programs that include collaboration with teachers of STEM content to support ELs' grade-appropriate STEM content and language learning

Teacher Educators and Professionals involved with Pre- and In-service Teacher Learning

Develop resources for teachers, teacher educators, and school/district leaders that illustrate productive, research-based instructional practices

Preservice Teacher Education and Teacher Credentialing Programs

Measure teacher knowledge of large-scale STEM assessment interpretation, classroom summative task design, and formative assessment practices with ELs

Conclusions 16-17: Families and Communities

- Persistent family-school connections essential for promoting students' educational attainment
- Cultural, linguistic, & social differences cited as barriers

Recommendation 5: Schools & Districts

- Help families/caregivers understand available STEM instructional programs & opportunities
- Form external partnerships (informal STEM learning opportunities) to better understand EL families' & communities' assets & needs

Conclusions 18-19: Large-Scale Assessment

- Linguistic heterogeneity challenge to obtaining accurate measures of academic achievement
- Multiple sources of info, multiple test scores, &/or qualitative assessment help inform decisions
- Individualized accommodations yield better-informed decisions about ELs' STEM achievement
- Changes needed: address EL characteristics, develop STEM assessment instruments, analyze & interpret info from tests, prepare teachers to design & interpret STEM classroom assessments

Recommendation 6: Design comprehensive and cohesive STEM assessment systems

Developers of Large-Scale STEM Assessments

- Develop and use population sampling frameworks that better reflect heterogeneity of EL populations
- Ensure proper inclusion of statistically representative samples in process of test development

Decision Makers, Researchers, Funding Agencies, and Professionals in Relevant Fields

- Develop standards on numbers and characteristics of students that need to be documented and reported on in projects and contracts involving EL STEM assessment

Recommendation 7: Review accommodation policies and develop accessibility resources

States, Districts, and Schools	States, Districts, and Schools	States and Districts	States developing new STEM assessments
• Review existing policies regarding use of accommodations during accountability assessments • Ensure ELs afforded access to linguistic accommodations that best meet their needs during instruction and assessment	• Examine implementation of accommodations to ensure implemented with high fidelity for all ELs • Take steps to improve implementation with high fidelity is not realized • Improve poor implementation when present	• Involved in developing new or revising existing computer-administered assessments: • Develop to incorporate accessibility resources rather than rely on accommodations	• Apply universal design principles in initial development and consider ELs from the beginning

Conclusions 20-21: Classroom Summative and Formative Assessment

- Classroom summative STEM assessment:
  - incorporate static visuals (e.g., graphics, pictures)
  - incorporate dynamic visuals (e.g., video)
  - divide tasks into multiple parts
  - engage students in collaborative tasks
- Formative assessment:
  - Documented non-STEM positive outcomes
  - Limited evidence to conclude outcomes generalize to STEM subjects with ELs
  - No reasons to suggest does not also work for STEM disciplines & ELs' learning.

Recommendation 4: Develop high-quality STEM curricula and formative assessment

Curriculum Developers, Educators, and EL Researchers

- Work together to develop curricular materials & resources that consider diversity as materials are being developed and throughout the design process

EL Researchers, Curriculum Developers, Assessment Professionals, Teacher Educators, Professional Learning Providers, and Teachers

- Work collaboratively to strengthen teachers' formative assessment skills to improve STEM instruction and promote ELs' learning

Conclusions 22-24: Impact of Educational Policies

- Policies at *ALL* levels facilitate or constrain STEM teaching/learning opportunities
- Successful school districts:
  - Design/implement structures → integrate language & content
  - Examine ELs' access to STEM coursework & content
  - Consider appropriate PD for teachers
  - May require flexibility with fiscal & human resources
- School district leadership is critical in facilitating coherence

Recommendation 1: Evaluate current policies, approaches, and resources

Federal Agencies
- Evaluate research & development funding allocation
- Enhance efforts that foster pipeline & training programs to increase # of qualified teachers

States / Districts
- Evaluate EL definition
- Include proper specification of entrance/exit procedures
- Examine policies & procedures for implementing state criteria

States
- Evaluate policies associated with:
  - Timing of large-scale state assessments & waivers
  - Frameworks for teacher certification
  - Distribution of financial & human resources

District Leaders & School Personnel
- Examine program models & EL placement in STEM courses
- Preparation of teachers
- Opportunities for teacher collaboration & professional development
- Distribution of financial & human resources

Schools
- Evaluate ELs’ success in STEM classes
- Quality of STEM classroom instruction
- Qualifications of teachers hired
- Professional development opportunities
- Resources allocated to STEM learning

Capacity Building: District/School Level

- Organizational Culture
  - Local norms, routines, & practices that shape district/school culture
  - Expectations for educator professionalism, collaboration, & reflection
- Educator Capability
  - Educators' beliefs & expertise influence ability to implement curriculum, strategies, & other practices
- Policy & Management
  - Appropriate funding, resources, scheduling, staffing, & allocation of responsibility

Recommendation 2: Develop high-quality framework to identify and remove barriers

Districts and School Leaders

- Identify and enact norms of shared responsibility
  - Within district central offices and within schools
- Developed by teams of district and school leaders

States

- Take active role in collecting and sharing resources across schools and districts

State/District/School Leaders

- Continuously evaluate, monitor, and refine policies to ensure ELs' STEM learning outcomes comparable to never-EL peers

Questions?

UPCOMING ACTIVITES

- Webinar Series
  - Dec 12: Teacher Professional Learning
  - Jan 10: Classroom Instruction & Assessment
  - Jan 24: Building Capacity
  - Feb 22: Large-scale & Classroom Assessment
- Release Events
  - CA: January 14, 2019
  - DC: February 12, 2019

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