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
<table>
<thead>
<tr>
<th>COMMITTEE</th>
<th>STUDY STAFF</th>
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<tbody>
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<td>CHRISTINE CUNNINGHAM</td>
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<td>Museum of Science, Boston</td>
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<td>MEGAN HOPKINS</td>
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<td>JUDIT MOSCHKOVICH</td>
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<td>WestEd</td>
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<td>MARY SCHLEPPPEGRELL</td>
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<td>University of Michigan</td>
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<td>GUILLERMO SOLANO-FLORES</td>
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<td>Stanford University</td>
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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)

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

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

Percentage of public school students who were ELs by state


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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

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

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

- 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:** What it's about

**Relationship:** Who is involved

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.

**Modalities:** How meaning is presented

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

**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.
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.
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

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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**
- 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

**States, Districts, and Schools**
- Examine implementation of accommodations to ensure implemented with high fidelity for all ELs
- Take steps to improve implementation with high fidelity when not realized
- Improve poor implementation when present

**States and Districts**
- Involved in developing new or revising existing computer-administered assessments:
  - Develop to incorporate accessibility resources rather than rely on accommodations

**States developing new STEM assessments**
- 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

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

Curriculum Developers, Educators, and EL Researchers

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

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

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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

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

Districts and School Leaders

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

States

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

State/District/School Leaders

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UPCOMING ACTIVITIES

• 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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