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

Sponsor: National Science Foundation
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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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
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

<table>
<thead>
<tr>
<th>Home Language</th>
<th>Number of ELs</th>
<th>Percentage distribution of ELs</th>
</tr>
</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>

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></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>
</tr>
</tbody>
</table>

### Science Course Completion

<table>
<thead>
<tr>
<th></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>

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

Data from HSLS:2009 High School Transcript Study

# ELSTEM
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

Relationship: Who is involved

Relationships: Shaped by role, status, formality, grouping

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.
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.
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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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

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

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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
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

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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

- Within district central offices and within schools
  - Developed by teams of district and school leaders

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

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

States

Districts and School Leaders

State/District/School Leaders

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UPCOMING ACTIVITIES

- National Science Teachers Association (NSTA) Virtual Conference (May 4)
- Presentation at American Society for Engineering Education (June)
- NSTA STEM Expo & Forum (July)

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Questions?
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EXTRA SLIDES
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