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ELLs and STEM Education

ENG 770 - CONTEXT CULTURE TEACHING ESOL

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Within the scope of STEM-based subjects—Science, Technology, Engineering, and Mathematics—English Language Learners, particularly long-term ELLs, are a demographic that has under-performed relative to their non-ELL peers. This paper will examine several of the issues that encumber ELL success with regards to STEM. It will also address current solutions available locally and nationally, as limited as they may be, in closing that widening gap.

The main purpose of this document is to create a social awareness program that bridges ELLs and their community to STEM-based knowledge. By promoting lessons, activities, and opportunities with local programs, this project will springboard home-school partnerships, encourage ELLs and their families to invest in secondary language acquisition, and motivate them to think of solutions affecting their community. Additionally, we will conclude by offering ideas to foster outreach, support service-learning opportunities, and continued exploration in this important area of ELL development.

Background on ELLs and STEM

To better understand how ELLs relate to STEM, it is necessary to have an idea of how they operate within correlating subjects in the United States of America. The U.S. Department of Education's National Center for Education Statistics provides several data sets that shed light on the assessment-based performance of ELLs in STEM.

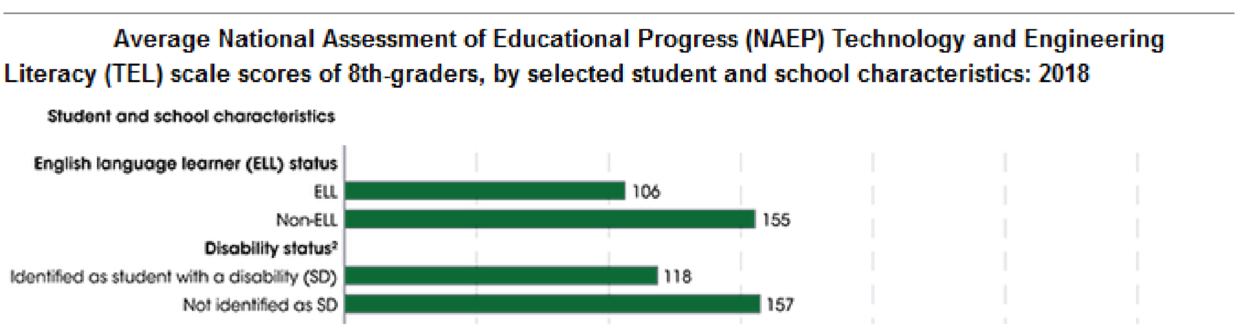
Using information from the National Assessment of Educational Progress (NAEP), which analyzes student performance in science at grades 4, 8, and 12 in both public and private schools across the nation, we can document how ELLs are performing in relation to their peers. With science, the NAEP measures students' knowledge along three content areas: physical science, life science, and Earth and space sciences.

As the report details:

> "Since 2009, the average science scores for English language learner (ELL) 4th- and 8th-grade students were lower than their non-ELL peers' scores. At grade 4, the achievement gap between non-ELL and ELL students was larger in 2009 (39 points) than in 2015 (36 points). At grade 8, the 2015 achievement gap (46 points) was not measurably different from the gaps in 2009 and 2011. At grade 12, the average scores for non-ELL students in 2015 (152) and 2009 (151) were higher than their ELL peers' scores in those years (105 and 104, respectively). The 47-point achievement gap between non-ELL and ELL 12th-grade students in 2015 was not measurably different from the gap in 2009."[1]

To recap: in science-based assessments ELL students perform significantly lower than their non-ELL classmates, with 46 points separating the two groups at grade 8, and a 47-point difference at grade 12, a gap that showed no measurable difference from 2009 to 2015.

For measuring aptitude in technology and engineering, the NAEP uses a Technology and Engineering Literacy (TEL) assessment. It is designed to indicate how students would apply skills in real-life situations over three content areas. In brief, they are the effects technology has on our world, simple principles that govern engineering, and the use of computers for creative communication. Students in grade 8 at both private and public schools were incorporated in the assessment.



[1] The Condition of Education: Science Performance, 2017.

In 2018, the NAEP scaled the scores of the TEL. Non-ELL status students averaged 155 points while students with the ELL status average 106, a difference of 49 points. The average of 106 was the lowest of all the student and school characteristics listed—lower than that of students identified as with a learning disability (118 to 106), the latter defined as being on an Individualized Education Protocol or a 504 program.[2]

Mathematics proved to be the most robust STEM category that the NAEP tested, with scaled scores dating from 1990 to 2019 at the 4th, 8th, and 12th grade levels. The scaled scores for ELLs, however, are only available for the years 2015 and 2019 for specific grades:

> "In 2019, the average mathematics score for 4th-grade ELL students (220) was 24 points lower than the score for their non-ELL peers (243). The average mathematics score in 2019 for 8th-grade ELL students (243) was 42 points lower than the score for their non-ELL peers (285). In 2015, the average mathematics score for 12th-grade ELL students (115) was 37 points lower than the average score for their non-ELL peers (153)."[3]

These assessments indicate that ELL students are the lowest performing demographic across all STEM categories, including high poverty. While other demographics show an improvement over the years, ELLs show no measurable difference in closing the gap with their non-ELL peers.

Little National Support for ELLs in STEM

On December 4, 2018, the Executive Office of the President of the United States issued a press release claiming STEM as an educational priority. The National Science & Technology Council

[2] The Condition of Education: Technology and Engineering Literacy, 2019.
[3] The Condition of Education: Mathematics Performance, 2020.

published a five-year plan titled "Charting A Course for Success: America's Strategy for STEM Education." It states that:

> "The Nation is stronger when all Americans benefit from an education that provides a strong STEM foundation…Even for those who may never be employed in a STEM-related job, a basic understanding and comfort with STEM and STEM-enabled technology has become a prerequisite for full participation in modern society."[4]

Noting the unequal access to STEM resources, and that racial and ethnic groups represent "27% of the population but comprise only 11% of the STEM workforce," the plan's acknowledgement of the limitations to STEM is important to mention. The federal report concludes by enacting a clarion call for all stakeholders, explicitly stating that strategies need to be tailored to different ecosystems. In the entire 38-page document, however, there is no mention of ELL, ESL, LEP, or any language-support for STEM. Instead, research indicates that the United States appears to be more inclined with recruiting international STEM candidates at the college level rather than cultivating them within their borders.

Because so many of the employment opportunities orbiting STEM demand high-education degrees, U.S. companies look to international college students to meet the growing demand. The United States is the number one destination for international students[5]. In fact, hosting international students resulted in a boon for the U.S. economy; foreign students and their dependents contributed more than $13 billion to U.S. commerce in 2004-2005.[6] The heyday of the U.S. as a desirable locale for STEM candidates, however, may have reached its zenith as competition for this work force is increasing.

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[4] Charting a Course for Success: America's Strategy for STEM Education, 2018.
[5] Batalova & Zong, International Students in the United States in 2015, 2016.
[6] Batalova, The "Brain Gain" Race Begins with Foreign Students, 2007.

Between graduating with the necessary coursework, undergoing Optional Practical Training upon completing collegiate studies, finding an employer willing to sponsor an H-1B visa, and then doing that job while navigating the U.S.'s shifting immigration policies, the steps toward entering the U.S. workforce as a non-citizen are certainly daunting. Today, international students are faced with a depreciating prospect of remaining in the United States, as a report states that "even for the best and brightest, the path to long-term residency can be lengthy, expensive, and uncertain…International student perceptions of the United States are growing more negative, which could increase their chances of leaving."[7]

Coupling this reality with the suspension of the H-1B visa system in 2019,[8] the lack of improvement from U.S. students in math and science over the past decade, other countries raising the global standard until the United States ranks outside the top ten in STEM-related assessments,[9] the systemic issue of a STEM labor shortage within the U.S. is a known problem:

> *"By 2050, today's minorities will be the majority. Simple math tells us that if we do not increase the number of women and minorities earning STEM degrees and participating in the STEM workforce at all levels, we will experience dire workforce shortfalls in the not too distant future. Some companies in the technology sector tell me the shortfall is already here."*
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> — House Science Committee Chair Eddie Bernice Johnson (D-TX), March 6, 2019

While the United States welcomed international talent throughout much of the 21st century, the brain waste of neither cultivating nor providing adequate STEM support in the established ELL population has resulted in even greater opportunity cost. The United States has forgone $39.4 billion in annual earnings by under-employing its skilled immigrant population.[10] It would

[7] Klimaviciute, To Stay or Not To Stay: The Calculus for International STEM Students in the United States, 2017.
[8] Bovard, Donald Trump right to suspend guest worker visas—American STEM workers deserve to work, 2019.
[9] Johnson, Maintaining U.S. Leadership in Science and Technology, 2019.
[10] Bachmeier, Batalova & Fix, The Costs of Brain Waste among Highly Skilled Immigrants in U.S., 2016.

behoove the United States to invest in STEM programs in the K-12 public school population, and particularly for ELLs to plug this drain.

Challenges ELLs face in Public School

According to the NCES, students who categorized as ELL made up 10.1 percent of the U.S. public school K-12 population as of the Fall of 2017. This ranged from a low of 0.8% of students in West Virginia to a high of 19.2% of students in California. In total, ELLs made up 5 million students in 2017, an increase of 1.2 million from the year 2000.[11] By 2025, 1 out of every 4 students in public education will be classified as ELL.[12] Despite this, the existing support networks and model programs at the local and national level leave ELLs with a handful of limited options with regards to STEM.

In the consensus report English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives published in 2018, the advantages of instilling STEM knowledge to the ELL population is called upon in the preface:

> "Increasing the diversity of the STEM workforce confers benefits to the society as a whole, not only due to the improved economic circumstances for a substantial segment of society, but also because diversity in the STEM workforce will bring new ideas and new solutions to STEM challenges. Organizing schools and preparing teachers so that all students can reach their full potential in STEM has the potential to transform the lives of individual students, as well as the lives of the teachers, the schools, and society as a whole."[13]

The study goes on to document the problems that inhibit ELLs. Heterogeneity among the population, a demographic that covers 150 languages, prevents a one-size-fits-all approach. Even

[11] The Condition of Education: English Language Learners in Public School, 2020.
[12] NEA Policy Brief: English Language Learners Face Unique Challenges, 2008.
[13] English Learners in STEM Subjects, 2018, pages *ix-x*.

among Spanish-speakers, a group that makes up more than three-quarters of the ELL population, individuals differ in their abilities across the four language modalities (listening, speaking, reading, and writing) due to nuances within each individual experience.

Of particular note are long-term ELLs whose English skills have plateaued before entering high school. Facing embedded barriers to STEM learning through their placement in remedial courses and lack of access to technology excludes them from the science or math courses necessary for STEM advancement. Too often students who have their Basic Interpersonal Communication Skills lack the Cognitive Academic Language Proficiencies necessary to be successful. Explaining the importance of developing these skills is tied to motivation, time, and building a lasting relationship with the content matter. For teachers this means making sure their biases and beliefs do not laden the learning outcomes of their English learners.

> "Part of the problem for teachers is that they have not received adequate preparation to provide STEM-related learning opportunities for English learners in their classrooms. When teachers consistently support and incorporate English learners into classroom activities, English learners have better outcomes. English learners should also be considered at the beginning and throughout the design of curricula for STEM courses. The report also found only a few states have systemic policies or programs to help teachers with their professional development in STEM related to English learners."[14]

Local Support for ELLs

A local program was developed by the University of Massachusetts to better train teachers on STEM-focused enrichment. Tied to the state's licensure requirement, this Sheltered English Instruction Endorsement was created by UMass Boston and its partner The Center of Science and Mathematics in Context (COSMIC). Together the two created the Rethinking Equity and Teaching for English Language Learners or RETELL. By providing two graduate certificates in

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[14] Friedman, STEM Outcomes for ELLs Fail to Meet Expectations, 2018

the Teaching of Math to ELLs and the Teaching of Science to ELLs, the programs provide teachers with standards-based instructional strategies that research has demonstrated are effective in improving ELL students' STEM performance.[15]

The issue with this program, however, is that it relies on SEI as the scaffold for teacher instruction, a policy widely looked upon as a failure for ELLs. One report that reviewed a decade of SEI in Arizona detailed the program model as "structurally restrictive, lacking sensitivity to age and grade level differences, as well as to the linguistic and cultural needs of emergent bilinguals."[16] Locally, one need only look at the declining MCAS scores and graduation rates of ELLs from 2002 to 2017 due to the restrictive English-only, SEI-centered policy known as Question 2.[17] The decline in ELL performance due to SEI practices was swift and alarming. As the 2010 report titled In the Aftermath of Question 2: Students with Limited English Proficiency in Massachusetts by Antoniya Owens states in its executive summary:

> "In academic year 2008, 81.1 percent of the state's LEP students attended sheltered English classrooms. Seventy percent of all school districts in the state had 90 percent or more of their LEP students in SEI programs… Overall, LEP students have fared worse than their English-proficient peers in terms of school engagement. Between 2006 and 2008—the only three years for which these data are available—LEP students attended school at rates similar to all students but were increasingly more likely to be suspended compared with English-proficient pupils. In 2006, LEP students' suspension rate was 16 percent higher than the rate of their peers; in 2008, it was more than a quarter higher…LEP students were also considerably more likely to repeat a grade and to drop out of high school. And while the grade retention gap between LEP and English-proficient students declined over time, the dropout gap increased noticeably. In 2003—the only year prior to Question 2 for which dropout rate data are available—high school students with limited English skills dropped out at a rate nearly twice as high as their English-speaking classmates. By 2006, their rate had risen steadily and was more than three times as high."[18]

What, then, is the solution for ELLs and STEM?

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[15] UMB & COSMIC, Teaching STEM to English Language Learners, 2020.
[16] Cruze, A decade after institutionalization: educators' perspectives of structured English immersion, 2019.
[17] Glatter, Massachusetts Legislature Passes Bilingual Education Bill, 2017.

[18] Owens, The Aftermath of Question 2, 2010, page 2.

Motivating ELL Communities to believe in STEM

In October of 2020, the Executive Office of Education and the STEM Advisory Council, in partnership with the state's nine regional STEM networks, unveiled its annual Mass STEM Week. The theme for its third iteration was "See Yourself in STEM." Focusing on the power of mentors, it mentioned English language learners as an example of those who are underrepresented in STEM industries:

> "Women, people of color, first-generation students, low-income individuals, English language learners, and people with disabilities are underrepresented in STEM industries and make up an increasing portion of the overall workforce, but the demographics of STEM fields have remained largely the same. We need more young people to see themselves…in STEM fields to pursue STEM careers as well as bolster their persistence through STEM education with a mentor that is engaged, supportive, and shares in the many unique parts of their identity."[19]

A consistent recommendation for ELLs in STEM education is mentor-led interaction with the content material. Having grassroots buy-in is also integral for there to be a lasting and constructive relationship between the ELL and STEM communities. ELLs, however, are not an easy demographic to reach. As mentioned, its heterogeneity demands multiple avenues for interaction.

While top-down shifts in how ELL is administered has largely failed its intended target audience, bottom-up solutions have proven effective with measurable success. In Owens's report on the consequences of Question 2, she spotlights Fuller Middle School in Framingham as a school that has bucked the trend of SEI failure due to its method of both valuing and investing in its bilingual community:

> "To provide LEP students with more options, schools in the district specialize in different approaches to English language support; Fuller is the district's "lab for new approaches." Fuller Middle School has a hybrid ESL/Bilingual/Sheltered English program divided into five stages:

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[19] Mass Stem Week, 2020.

> ESL 1-2 through ESL 5. The initial level offers native-language instruction of math, science, and social studies, with everything else in sheltered English…. Fuller Middle School's approach to educating LEP students is in large part a community endeavor. Trilingual counselors, community-based service providers, graduate interns, and volunteer tutors collaborate to offer students continuous and wide-ranging support. Fuller also hosts an adult ESL program attended by many immigrant parents. Finally, it keeps families engaged through a series of evening events as well as new parent orientations—which, to increase access and inclusivity, offer both transportation and translation services…The academic performance of Fuller's limited English-proficient students is marked by continued excellence."[20]

This model example is one that more schools and districts should adopt, especially in Massachusetts. With its world-class institutions, international vibrancy, and history of educational leadership, the area is fertile for mentors to connect and cultivate ELLs into STEM.

What can we do?

Create a district-wide STEM ELL day early in the school year to gain traction and establish relationships within the school community and local STEM-based opportunities. This would be an ELL-directed mission partnering with the Science, Technology, Engineering and Mathematics departments to organize connections between potential mentors from local fabrication labs, trade schools, and service programs. Students and their families would work alongside translators and community leaders to complete interactive activities such as the spaghetti tower marshmallow challenge and the egg drop test with the goal to tie ELLs' native language and culture as an integral asset to solving the STEM problems set before them.

A true clarion call would follow. To bring new ideas and new solutions to STEM challenges, the following quote should instill teachers and mentors with a foundational stepping-stone:

[20] Owens, 36.

> "Since ELL students are emerging bilinguals (or may already be multilingual before learning English), ELL students in class are already utilizing more of their brain function than other students. So, we challenge STEM teachers to view having ELL students in one's class as having gifted students in the class. Native English-speaking students benefit socially and especially academically from having interaction with ELL students in their class."[21]

Showcasing stories of how STEM and ELL solved problems in international communities, such as the iron fish in Cambodia[22] or the electricity-generating playground equipment in Ghana[23], this call to action would ask those in attendance to think of solutions to problems within their local districts. Teachers would supply lists of Tier 2 and Tier 3 vocabulary in English and the languages represented to promote bilingual literacy. This would support the cognitive underlying proficiency of not just students but also their families. Finally, public health care officials would offer instructions for best practices and directions on general well-being to better service the population.

The reason and incentive are clear, as are the data and potential for growth opportunities. For STEM education to take a foothold in the ELL demographic it needs to be practically applied not just in an academic arena but in one that is closer to home, tied to family and culture, for the benefit of people that are often on the frontlines in providing integral services to local economy. As this COVID-19 pandemic has made clear, everyone benefits when STEM knowledge is understood and accepted. The time is now for ELLs to embrace STEM—and for STEM communities to embrace back.

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[21] Hoffman & Zollman, What STEM Teachers Need to Know and Do for ELLs, 2016, page 92.
[22] Roxby, Why an iron fish can make you stronger, 2015.
[23] Brownlee, A Merry-Go-Round That Turns the Power of Play into Electricity, 2013.

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