AMIR LOPATIN FELLOWSHIP FINAL REPORT

BILINGUAL ENGINEERING AND SCIENCE IN ONLINE LEARNING ENVIRONMENTS

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Executive Summary

In alignment with the Amir Lopatin Fellowship's mission to support "exceptional projects involving technology and education," this report presents one of such works completed thanks to the generous funding provided by this fellowship. This report presents data from a survey followed by an online learning experience focused on the role of language and cultural background in engineering. The study includes statistical analysis of survey data as well as qualitative analysis of semi-structured interviews of students. The work brings together methods and theoretical approaches from the learning sciences as well as science and engineering education to investigate *how students' perceptions of language in science and engineering influence their linguistic practices in online learning environments*. Because large portions of this work are currently under consideration in peer-reviewed journals, the report will primarily focus on high level observations but I will forward to sharing links to these future publications once available.

Introduction

The reasons why we teach science and engineering (S&E) are manifold, but can be summarized in the goal of preparing the next generation of professionals and developing informed citizens who make decisions and solve problems intelligently (DeBoer, 2000). The spread of the coronavirus (COVID-19) has rushed schools to move the execution of these goals online. Yet, an education that prepares future scientists, engineers and informed citizens remains inaccessible for many learners in offline contexts and very little is known of the situation in the virtual sphere. Oftentimes, science and engineering learning environments enforce language norms that privilege dominant ways of speaking (Rosebery, Warren, & Conant, 1992). This situation can alienate culturally and linguistically diverse students from developing their full

potential in the technical fields. Learning online can pose its challenges, especially if students are speakers of non-dominant varieties of language (Richards, 2020). The alienation of students from science and engineering is not the only consequence. We may also fail to equip these learners with the basic tools to understand the world and engage in knowledge generation and problem solving. The key to increasing access and inclusion of diverse communities in the technical fields may be within the learner. Scholarship suggests that we need to explore the affordances of students' background in virtual environments for learning engineering and science.

Today, education scholars believe either in English-only education or in language inclusivity for learning. The work presented in this report seeks to inform educators on the role that language plays in learning and social interaction in physical and virtual environments for learning, particularly in engineering and science. Proponents of English-only approaches to learning regard language as an avenue to access power. In their view, we help students by educating them under strict norms that favor dominant language(s). For them, separation of the languages is advantageous for mastering the ways of speaking in science and engineering and in society in general (Palmer et al., 2014). Contrary, promoters of language inclusivity claim to foster learners' conceptual development by valuing and leveraging students' language resources for learning (García & Kleyn, 2016). My research attempts to put the English-only education and language(s) inclusivity perspective in conversation, especially when it comes to online learning, thus giving rise to a new viewpoint in the context of STEM education. My research contributes to the learning sciences and provides practitioners with resources to understand how to serve diverse communities. It also creates foundational insights to the areas of science and engineering education and bilingual education. Specifically, it will expand the thin scholarship on online teaching and learning of children from immigrant communities in the technical fields. This work

will provide empirical data to the research question of *how students' perceptions of language in science and engineering influence their linguistic practices in online learning environments*.

This project proposes to investigate the relationship between language, cognition and social interaction of an online engineering design workshop. Building on my prior exploratory work on language in engineering, my research project investigated this relationship by understanding the experiences with language of linguistically diverse students and engaging them in engineering design in an English-only lesson or bilingual lesson (both Spanish and English). Through the project presented in this report, I seek to empower students in finding their voice in engineering and science online learning environments. Below, I describe how my proposed project may help us explore ways to support diverse learners as we navigate the current shift to online instruction.

Methods

This mixed-methods design has two stages of data collection: an online pre-survey on language use and an individual virtual engineering design task. Originally, the study planned for a third component of collaborative engineering design, but to the challenges posed by the pandemic, this work has been scheduled for future research. First, 196 Latinx students who grew up in Spanish-speaking households in the United States completed a pre-survey on perceptions of language use. All of them were pursuing a STEM pathway at the time of the study. Second, a subset of 26 students who completed the online pre-survey participated in the individual engineering task online. The students were randomly assigned into the English-only or bilingual condition to complete a set of design tasks. In this online assessment, students independently completed a task inspired by the Toaster Task (inspired by the work She & MacDonald, 2018)

and the Palo Alto Flooding Problem or PAFP (inspired by the work of Atman, Yasuhara, Adams, Barker, Turns & Rhone, 2008; Pérez, Gilmartin, Muller & Sheppard, 2019).

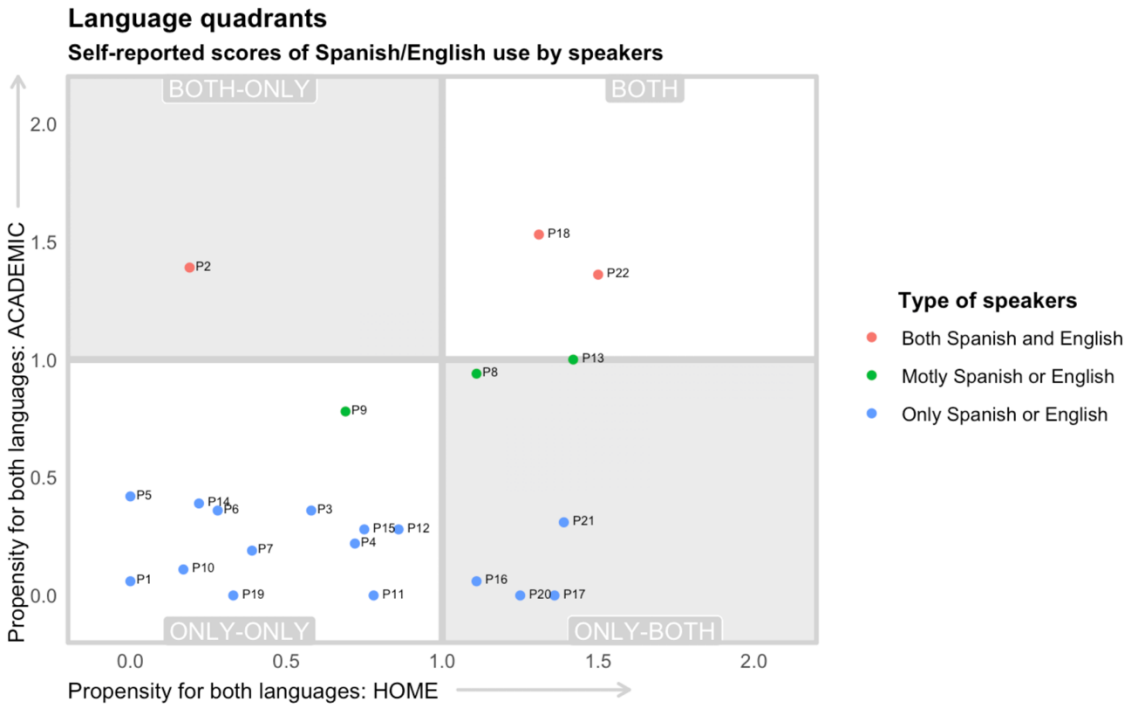
Measures

Following prior literature on bilingualism (Fishman, 1971; Mackey, 2000), this study uses a survey on students' self-perception of language use to understand their linguistic practices across contexts. Participants answer questions about different situations that include a combination of academic and/or home interlocutors, settings and topics. Language use was measured through items that asked participants to rate their likelihood of speaking English, Spanish or both languages in a variety of contexts (home vs. school), with different people (parents vs. teachers) and speaking about different ideas (family topics vs. math ideas). The survey asked participants to assume that they and all the people mentioned live with two languages, both Spanish and English, which they know equally well. Using the survey data, the study identified language patterns of use in home or school contexts as shown in the example of Figure 1, which presents data predating this study used to model the performance of the survey items[1]. Figure 1 shows that the closer the score in the language survey is to two, the more likely students reported to speak both English and Spanish in a setting. Conversely, if the score is closer to zero students reported speaking either English or Spanish only in their academic or home context. The need of having a participant pool with similar language profiles became clear to me after a previous study on the use of two languages in engineering design. In this prior work, I observed that students who reported a high frequency of using both languages in different contexts and with different people were more likely to draw on their full language resources in the context of learning.

[1] As indicated in the executive summary, only high level observations about the results and/or examples of the kinds of data manipulations used in the study will be included in this report.

Figure 1

Language quadrants by propensity of using both languages in academic and home domains using data from a pilot study to test the survey items



Data analysis & Results

Language use when speaking with a professor

The study documented a statistically significant difference between students pursuing a pathway in STEM depending on their home language with respect to the language they would use when talking with a professor (see Table 1). Those who reported growing up in a predominantly Spanish-speaking household were more likely to speak using both languages, English and Spanish, with a professor (in contexts and about topics related to home and academics). Two other factors related to the language spoken at home were also statistically significant: Self-reported English

Language Learner (ELL) status in K-12 school and participation in a bilingual education program during their K-12 education (see Table 2 and Table 3). We considered the analysis of these two different factors as highly related to the language spoken at home because the latter is the decisive element in labeling students in schools as bilinguals and/or ELLs. For the purposes of this work, we described bilingual education as a traditionally elementary compensatory program that includes only Latino/a/x students. Other factors such as students being labeled as English Language Learners in schools also relies on the question of what is the language spoken at home.

Table 1

Participants who grew up in households with different degrees of spoken Spanish

(t = 3.0034, df = 29.799, p-value = 0.0054)

	Spanish-dominant home (n = 173)	**English-dominant home** (n = 23)	
Mean	0.56	0.26	**
Median	0.44	0.03	
Standard deviation	0.51	0.45	

* p-value < .05, ** p-value < .01, ***p-value < .001, for difference within group pre/posttest change generated with a paired two-sided t-test.

Table 2

ELLs' differences in language use when speaking with professors

(t = 2.6932, df = 189.16, p-value = 0.007)

	ELLs (n = 112)	**Non-ELLs** (n = 84)	
Mean	0.61	0.42	**
Median	0.5	0.25	
Standard deviation	0.53	0.46	

* p-value < .05, ** p-value < .01, ***p-value < .001, for difference within group pre/posttest change generated with a paired two-sided t-test.

Table 3

Bilingual students' differences in language use when speaking with professors

(t = 2.151, df = 139.5, p-value = 0.0332)

	Bilingual (n = 69)	**Others** (n = 127)	
Mean	0.63	0.47	*
Median	0.56	0.28	
Standard deviation	0.5	0.5	

* p-value < .05, ** p-value < .01, ***p-value < .001, for difference within group pre/posttest change generated with a paired two-sided t-test.

Language use when speaking with a professor <u>in engineering</u>

There is a statistically significant difference between students pursuing a pathway in engineering and other STEM students with respect to the language they would use when speaking with a professor (see Table 4). Engineering students reported to be less likely to use both English and Spanish when speaking with a professor. In the interviews that followed the survey, students described their preference for English in language use in the virtual learning environment as driven by their need to remain objective and professional. Students described English as the language of choice when focusing on the technical, which they associated with the field and described as detached from the person. They also attributed the prevalence of the dominant language to issues of inclusion and diversity in engineering at large.

Table 4

Engineering and non-engineering STEM students

(t = -3.1596, df = 175.5, p-value = 0.0018)

	Engineers (n = 73)	**Non-engineers, STM** (n = 121)
Mean	0.39	0.61 **

Median	0.25	0.50
Standard deviation	0.43	0.53

* p-value < .05, ** p-value < .01, ***p-value < .001, for difference within group pre/posttest change generated with a paired two-sided t-test.

Other observations

An interesting initial finding signals the potential difference by gender in language use when speaking with a professor but additional research needs to be done to further investigate this pattern. When compared to male and non-binary students, women were more likely to report speaking both languages in academic settings (see Table 5). However, these differences were not statistically significant. Additional data in the study of language use in virtual spaces suggest that students equated speaking Spanish with using both languages. Although participants described English as the dominant language in science and engineering and a marker of professionalism, students stated that using both languages keeps them connected with their background and communities. Some students explained that the answer of being linguistically inclusive goes beyond simply incorporating non-dominant language(s) such as Spanish and Spanglish in virtual learning environments.

Table 5

Gender differences in language use when speaking with professors

(t = -1.8322, df = 124.02, p-value = 0.0693)

	Women (n = 132)	**Man and non-binary** (n = 64)
Mean	0.58	0.43
Median	0.48	0.25
Standard deviation	0.5	0.51

* p-value < .05, ** p-value < .01, ***p-value < .001, for difference within group pre/posttest change generated with a paired two-sided t-test.

Discussion & Conclusion

This project seeks to contribute to improving the quality of online science and engineering education, increasing access to the technical fields for underrepresented groups in STEM, especially linguistically minoritized populations, and incorporating the wealth of knowledge from the communities in the process of solving problems. In the broader sense, this research contributes empirical data to the scholarship that tackles issues of technology, diversity and community. In alignment with prior scholarship (NAE, 2002; Phillips, 2014), the work presented in this report makes the argument that the inclusion of engineers and scientists from different backgrounds demand us to look at broader social justice issues of language, culture and representation for imagining equitable spaces for learning. My work evolves from my experiences and insights as an Afro-Latina engineer and bilingual teacher. My research agenda seeks to support educational leaders in helping diverse students to be heard and to contribute, thus encouraging them to pursue careers in engineering and science. The funds from the Amir Lopatin Fellowship enabled me to advance this mission.

Closing Thoughts and Acknowledgements

Thanks to the gift from the Amir Lopatin Fellowship, I was able to complete the final studies of my dissertation work in the midst of a global pandemic. The Amir Lopatin Fellowship was used to support part of the data collection and analysis described in this report as well as research activities not described in this report due to copyright. Without this funding and the unconditional support of the community and faculty members in the Learning Sciences and Technology Design program at Stanford, the continuation of my work in engineering education may have not been possible. I also wish to acknowledge the students who volunteer their time as participants in this work and my PhD students colleagues who provided valuable feedback.

Gracias to my former students in K-12 schools in North Texas and Northern California for being a constant source of inspiration (even after so many years) to question the educational realities of our country and invite me to imagine futures through my research where we all learn with dignity. These students are my inspiration for working towards a transformative engineering education.

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