¿Por qué no los dos? The Importance of Translanguaging in Bridging Language, Literacy, and Engineering

Dr. Joel Alejandro Mejia, University of San Diego

Dr. Joel Alejandro (Alex) Mejia is an assistant professor in the Department of Integrated Engineering at the University of San Diego. His research has contributed to the integration of critical theoretical frameworks and Chicano Cultural Studies to investigate and analyze existing deficit models in engineering education. Dr. Mejia's work also examines how asset-based models impact the validation and recognition of students and communities of color as holders and creators of knowledge. His current work seeks to analyze and describe the tensions, contradictions, and cultural collisions many Latinx students experience in engineering through testimonios. He is particularly interested in approaches that contribute to a more expansive understanding of engineering in sociocultural contexts, the impact of critical consciousness in engineering practice, and development and implementation of culturally responsive pedagogies in engineering education.

Melissa M. Arana
Mireya Becker Roberto, University of San Diego
Miss Nicole G. Reyes

¿Por qué no los dos?
The importance of translanguaging in bridging language, literacy, and engineering

Abstract

The changing demographics of the United States has led to a dramatic increase in the number of students from different linguistic backgrounds. However, due to the prescriptive nature of language and the establishment of language policies in the U.S. educational system, English continues to be the "privileged" language for STEM while equal access opportunities continue to decrease. Although English Language Learners and Emergent Bilinguals are interested in – and can understand – STEM concepts, the lack in English proficiency is often assumed to be the limiting factor in getting students to engage in STEM activities. Thus, it is important for educators to appreciate and acknowledge the linguistic repertoires of students as they engage in STEM activities. In an effort to help teachers recognize these linguistic assets, this project sought to create an environment where English and Spanish could be used as tools for meaning- and sense-making. The goal of this study is to inform how teachers can design engineering activities that consider ELLs needs. In this paper, we present an example of how translanguaging practices of teachers contributed to the understanding of science and engineering practices and the application of engineering design processes in the classroom.

Introduction

The population of Latinxs in the United States has grown exponentially in recent years. Many of these individuals can exist transnationally, thus never having to cut ties with their familial exchanges, connections and practices across borders [1]. For instance, children of Latinx immigrants continue to embody cultural values, identities, and social practices that shape their own “understanding of belonging to two places simultaneously” [2, p. 77]. The emergence of transnational migration has also transformed our everyday interactions with others, and continues to influence public education in the United States. According to the U.S. Department of Education [3], Latinx youth is the fastest-growing segment of the U.S. adolescent population and is projected to become the number one minority in school enrollment.

Primarily influenced by transnational movements, the increasing number of school-aged Latinx students will lead to an increase of English Language Learners and Emergent Bilinguals that will eventually become the next generation of engineers. Thus, the changing demographics of the United States will demand new adjustments to public education. We have seen a growth of engineering curriculum added into K-12 education, as shown in new state standards for public education [4]. However, there remains a lack of equal access to STEM education and STEM learning opportunities for English Language Learners.

In this paper, we describe how linguistic practices are important for meaning and sense-making in STEM. For this study, seven teachers received 25 hours of professional development through an intensive workshop looking at asset-based approaches to engineering education. Teachers

used a combination of dynamic and fluid linguistic practices to describe how engineering and science practices are interconnected. We observed frequency translanguaging for meaning-making during the planning process, and a repertoire of teachers' linguistic strategies (both in English and Spanish) that served as a vehicle to identify, frame, and design the units for their curriculum. The purpose of this paper is to describe the importance of translanguaging in engineering classrooms when discussing meaning making.

Theoretical Foundations

Dual language is an umbrella term that refers to any program that provides literacy and content instruction to all students through two languages, promoting bilingualism and biliteracy, grade-level achievement, and multicultural competence for all students [5]. Often teachers find themselves hitting a barrier in STEM courses when it comes to incorporating dual language practices. There are limited opportunities for STEM content teachers and English as a Second Language (ESL) teachers to collaborate, particularly because STEM content teachers may see themselves providing only STEM content while dismissing any language-related responsibilities [6].

In recent years, dual language programs have expanded in the United States reflecting a better understanding of the connection between language and content knowledge [7]. Public schools have increasingly begun offering programs that highlight the importance of language to students going into primary schools. However, many of these programs are not in response to the increasing immigrant or linguistically diverse populations, but instead to further benefit English-speaking children [8]. As White, privileged parents and families of English-speaking students have increasingly recognized the benefits of dual language, they have been more interested in incorporating this style of education as an added form of education enrichment for their children and not necessarily to close the achievement gap [5].

But what most dual language education programs do not prepare students for is an already *bilingual* Chicanx and Latinx audience— an audience that reads, writes, listens, and speaks in both Spanish and English, and that sometimes disrupts the perceived boundaries between both languages [5]. Language is often perceived as a limiting factor for learning, that is, when the language in question is not English. According to Machado [9], "multilingual and multi-dialectical youths' linguistic resources are rarely valued in school writing, where mastery of Dominant American English remains the primary goal*"* (p. 35). This rhetoric, in turn, leads to many students' – particularly students of color – language (language other than English) to be either prohibited or marginalized thus resulting in linguistic discrimination and racism [10].

Hart and Risley [11] popularized the misguided notion that by 3 years of age, children from wealthier households were exposed to approximately 30 million more words than children from lower socioeconomic backgrounds. Their claim of a "word gap," also known as the "language gap" [11], has been used by many researchers and educators to explain the low academic achievement patterns of students from marginalized backgrounds. Through their argument, they suggested ways to correct the problem by increasing the number of words to be memorized or learned to reduce the achievement gap [11]. Absent in the "language gap" campaign, however, is

any mention of how schools are underprepared to accommodate students from linguistically and racially diverse backgrounds. Instead, "language gap" research and programs approach linguistic diversity as academically damaging and in need of remediation [12]. Taking into consideration that over 84% of U.S. teachers in U.S. public schools are White, and over 50% of students come from a minority background [13], the blame towards students and their families should instead be shifted to investigate the extent to which disparities in academic achievement are related to how schools are equipped to support students from diverse cultural, linguistic, and economic backgrounds [12]. Although knowledge construction is dependent on language practices, we still have not seen a push to increase advocacy for different linguistic abilities (e.g., not English) in STEM education. Martinez [5] argued that "by preparing students to engage with both monolingual English-speaking audiences *and* monolingual Spanish-speaking audiences, dual language education sends the message to students that both of these audiences are worth engaging with—that they are both groups of people that matter" (p. 88). Thus, recognizing the students' linguistic practices in the classroom could become a pathway to and through engineering for many students who are marginalized and do not see themselves reflected in STEM.

Positionality

Engineering as a profession is known for having a culture that thrives on uniformity and unquestioning of dominant discourses, thus leaving no space for multicultural perspectives and other ways of being and knowing. We recognize engineering as a practice that involves more than just technical aspects, but embedded in social and cultural practices. Failing to recognize this characteristic of engineering can lead to the dismissal of students' everyday lives, and the impact on the people of color who partake in engineering careers. Often, engineers and engineering educators fail to recognize the impacts of socio cultural practices in engineering, including those that emerge from transnational movements. In addition, the increase in transnational migration has propelled an anti-immigrant sentiment and sociocultural displacement from classrooms. That is, Latinx youth continue to be marginalized and excluded from educational opportunities that reflect and acknowledge their transnationalism.

As a research group comprised of researchers and students from multiple cultural backgrounds that are continuously underrepresented in STEM, we understand firsthand the necessity of increasing representation in this field. Due to our background, it can be noted that we likely notice the discrepancies in representation more than those who come from more represented cultural groups. However, we believe that students of all backgrounds should be able to picture themselves in a STEM career and have their own STEM identity.

We consider there to be a systemic issue in our education system that contributes to the ongoing underrepresentation of people of color in the STEM field. One of the factors contributing to this issue is the lack of recognition of different linguistic practices within the education system. The acknowledgement of translanguaging in engineering is almost non-existent primarily because English is seen as the *lingua franca* of engineering. Traditionally, linguistic practices are often perceived as limited to the household and not the classroom. We argue that deficit perspectives of language in engineering may continue to contribute to the disproportionate participation of

students of color in engineering. Equal access to engineering education includes not only increasing the number of students of color in the different engineering disciplines, but also attending to their needs and recognizing their linguistic, cultural, social, and historical backgrounds.

Context of the Study

Over the summer of 2019, a workshop was facilitated at Southwestern Border University (pseudonym) in collaboration with middle school teachers as a way to assist in curriculum co-construction. Seven bilingual teachers from a STEM-focused middle school located in the U.S.-Mexico border were invited to participate in this workshop with the main purpose of co-constructing engineering-focused curriculum materials. All seven of the participating middle school teachers were bilingual, and the majority taught their classes in a dual-language format, as is becoming more common in border city public education systems.

The middle school is located in a community near the U.S.-Mexico border where students travel across the international border twice a day to attend their classes. Language exchange is visible in the classroom, among students, teachers and administrators. Often the communities that meet from both sides of the border are Spanish speakers or minorities who face a "perceived" language barrier in STEM classrooms from a young age. Multilingual speakers use a combination of language as a complete communication system disregarding all social and political boundaries, which in this study we characterize as "translanguaging" [14]. "The term stresses the flexible and meaningful actions through which bilinguals select features in their linguistic repertoire in order to communicate appropriately" [15, p. 7].

The summer workshop was developed to introduce teachers to different approaches to integrate engineering into their classrooms while addressing the Science and Engineering Practices of the Next Generation Science Standards [4]. The workshop included an introduction to the basics of the engineering design and an overview of the Science and Engineering Practices. The workshop was also used as a way to instruct teachers on how to support English Language Learners and Emergent Bilinguals, and how to draw from students' funds of knowledge [16, 17] and language practices to develop curriculum. Funds of knowledge is a term used to describe the knowledge, skills and practices that students bring from home and how it can impact their studies in an academic setting [16, 17]. The application of funds of knowledge empowers kids by incorporating their wealth of knowledge, skills and practices into new contexts where they can see themselves reflected [18-20]. To that end, the teachers received some instruction on how to use funds of knowledge to create more culturally relevant classroom materials. One of the activities involved discussing among themselves their own funds of knowledge and how they would use those "life stories" to create relevant materials. The nutrition-related activity, which later became the thematic unit described in this paper, emerged from those conversations related to funds of knowledge.

Throughout the workshop, the teachers themselves came up with ideas and presented them to the research team to obtain feedback and together improve their thematic units. The teachers were split into different groups based on grade level, 7th, and 8th grade, so multiple disciplines were

present in each team. The group of teachers (all bilingual) consisted of three science teachers (one male and two females), one Language Arts/English teacher (female), one mathematics teacher (female), one Spanish teacher (female), and one social studies teacher (male). Table 1 shows the demographics of the teachers recruited to participate in this project (pseudonyms are used to indicate the names of participants). Teachers were able to collaborate with colleagues from different subject areas, and decided on a particular thematic unit to work on throughout the entire school year. The eight grade teachers decided to focus on "mars exploration" while the seventh grade teachers focused on the rearrangement of the school cafeteria. This paper focuses primarily on the seventh grade teachers because that is where we observed most of the linguistic practices being used in different contexts.

Table 1. Demographics of participating teachers

Participant	***Grade Taught***	***Subject Area***
Marco	8th	Science
Juan	8th	Social Studies
Martha	8th	Science
Alondra	7th	Science
Alexa	7th	Mathematics
Paulina	7th	English
Rocio	7th	Spanish

Methodology

The study presented in this paper is part of a larger study. Data were collected through observations, audio recordings and field notes. The teachers were divided into teams according to grade level, which allowed for a collaborative and diverse environment that facilitated discussion and listening to different perspectives. At the end of the workshop, the teams shared their thematic units with the teachers and researchers to receive feedback on their proposed ideas. The research team focused on the teachers' responses and reactions to funds of knowledge and the ways in which they envisioned implementation in their classrooms. In addition, the research team focused on the teachers' reactions to the science and engineering practices, particularly those teachers whose background was not STEM. Teachers from different subject and content areas were invited to participate to highlight the importance of language practices in STEM, and engineering in particular. We sought to create an opportunity for teacher to collaborate across disciplinary boundaries while acknowledging the importance of linguistic practices in sense making across subject areas. As indicated before, there are limited opportunities for bilingual education teachers to collaborate in STEM content development and STEM teachers dismissing the importance of language-related practices in sense making [6].

In addition to the observations, artifacts or products created by the teachers were collected. These included posters and lesson plans, among others. The teachers created lesson plans for each of their individual subjects and each lesson incorporated engineering topics. The research team used their engineering background to assist the teachers in this integration and then lesson plans were stored for further analysis. Data obtained from observations and fields notes were analyzed

using constant comparative analysis to identify trends in the data [21]. The results obtained from this analysis are described in the following sections. The next section focuses primarily on how teachers used these linguistic practices to make sense of a topic some of them had never heard about - the Science and Engineering Practices [4]. Future work will expand on some of the other components of the larger study, including language in the enactment of engineering.

Results and Discussion

Tanslanguaging for meaning and sense making

The seventh-grade teachers developed a thematic unit around the topic of nutrition. They themselves engaged in translanguaging as they tried to analyze nutritional facts on different labels. Their goal was to create an activity that would include the science and engineering practices (e.g., asking questions, analyzing and interpreting data, developing and using models, engaging in argument from evidence, etc.) while generating conversations about healthy choices. Along with the implementation of nutrition labels, one of the goals was to implement engineering practices in reducing waste and continuously improve the school cafeteria. The proposed improvements included a facility renewed layout, and re-organization of the menu in multiple languages to recognize diversity and incorporate healthier food choices. Figure 1 shows the different components of their thematic unit.

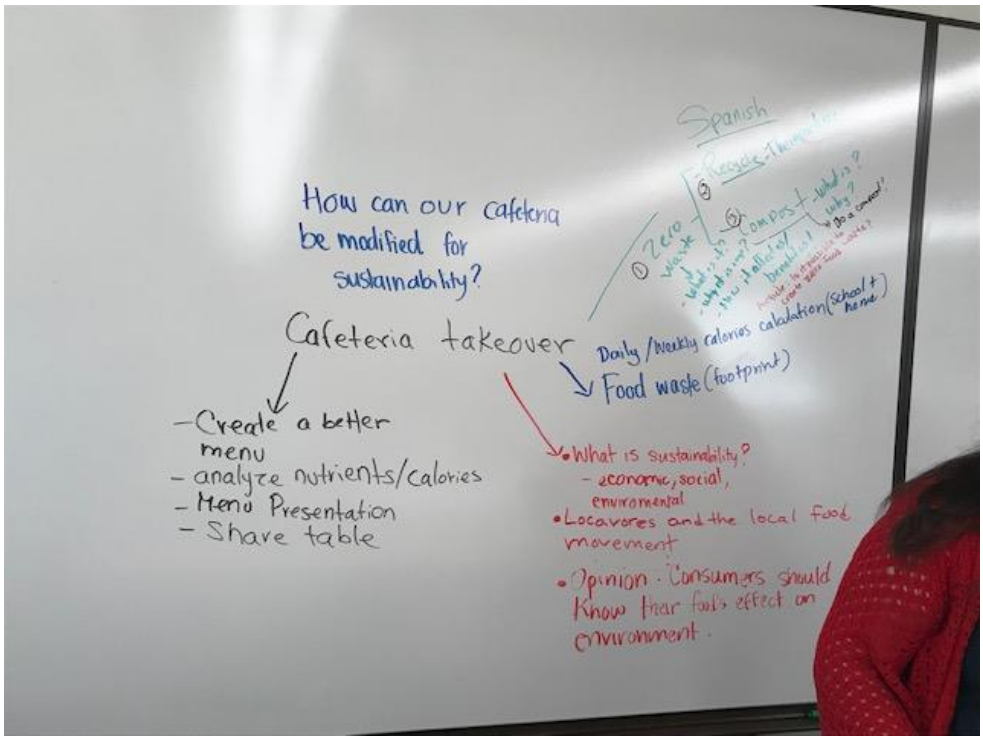

Figure 1. "Cafeteria Takeover" brainstorming session of 7th grade teachers

The data indicated that many of the teachers were using a series of linguistic practices (i.e., linguistic repertoire) as they communicated with each other. All of the teachers who participated

in the workshop were bilingual and most communicated to each other in both Spanish and English. The team of seventh grade teachers used translanguaging throughout the duration of the workshop when communicating to each other, mainly when discussing how they would incorporate engineering topics into their curriculum. For example, teachers would read content in English, such as the Science and Engineering practices [4] or information on sustainability and engineering, but discuss the content in Spanish. These fluid conversations led to more meaningful conversations that allowed both STEM and non-STEM teachers to exchange information that was beneficial for the development of their units. Translanguaging in this context was useful for communication because it allowed an expanded vocabulary to be used in discussions since English and Spanish words were used to provide context and descriptions, and as a way to further solidify an idea.

Organizing a meal plan and proposing a lean-six sigma (a term teachers searched for in both English and Spanish) project in a different language allowed for a better understanding of dual-language integration in engineering. Rocio, the Spanish teacher, for example, decided to incorporate engineering and art along with other components of the Spanish curricula she had developed to allow students to explore engineering in their native language. It consisted of reading and interpreting a scene of a story through either a drawing, a model or a sculpture, which aligned with the developing and using models in science and engineering practice. Rocio was not familiar with the Science and Engineering Practices but recognized that "engineers build models" after conversations in Spanish and English with the rest of the team members. These activities helped demonstrate that the language used in the classroom can be used in meaningful ways for sense-making, not just for teachers but also for students. The activities allowed the teachers to acknowledge that knowledge in engineering is not only created in English but also in Spanish, and that not having the "engineering background" is not an impediment to understand the engineering design process.

The group of seventh grade teachers who participated in the defining stage of the school cafeteria takeover took into consideration sustainability and social technical impacts for the development of their thematic unit. For some of them, it was the first time talking about these issues in depth. Gathering, synthesizing, and analyzing information involved the use of resources from different languages with very little regard for the politics of a typical classroom where English is given priority [15]. While the team included different categories in the process improvement project, often the discussions were a mix of English and Spanish. The teachers were using their own translanguaging practices, and were not restricted by the classroom's social and political boundaries [14]. One of the teachers, Rocio, indicated that "if it helps the teacher gather their thoughts and communicate clearly their ideas, then it certainly helps the students" as well.

Future Work

This study was part of a larger project that seeks to assess how teachers integrate funds of knowledge, linguistic practices and engineering design into their classrooms. Some of the teachers are part of the dual language or bilingual education program and constantly interact with students whose primary home language is Spanish. During some of the observations, the research team noticed that, although some of the teachers are not "allowed" to speak to students in Spanish, Spanish was used as a way to provide context to the curricular units implemented at

the school. There were indications that translanguaging was enacted by teachers and students alike, but certain policies or perceptions may prevent teachers from valuing or consenting for translanguaging to happen in the classroom. In addition, future work will explore the perceptions of teachers toward these practices given that some of the language instruction in schools is very prescriptive. The goal is to engage in conversations with teachers about the advantages of bridging language, literacy and engineering in classrooms where language has been perceived as a limiting factor for English Language Learners/Emergent Bilinguals to engage in meaningful STEM activities [7]. Future work will also document how language policies at the institution may or not allow teachers for more flexibility in STEM education.

This study sought to highlight the importance of linguistic practices in engineering. We highlight how the teachers, not the students, used translanguaging to make sense of topics, such as engineering and funds of knowledge, that are not familiar to them. Although a good level of trust was built on the teachers and they felt comfortable using a mix of English and Spanish during conversations, it is not clear how they may incorporate these same practices in their classrooms or how often they used the practices learned in the workshop. Future research will look into how linguistic practices look like in an engineering context in middle school classrooms.

Conclusion

Observing the teachers share their own experiences with dual-language within the classroom was an enriching experience that allowed us to gain a better understanding on the importance of incorporating different linguistic practices within our education system. Translanguaging has many contributions to the formation of engineering students and particularly for the professional development of K-12 teachers not trained in engineering.

Having different language practices does not stop the individual from creating engineering knowledge, in fact, allowing and encouraging students' everyday translanguaging would constitute a form of ontological recognition—a way of recognizing these students' ways of *doing and being bilingual* [22], and a way of recognizing their embodied knowledge and lived realities. If we only prepare kids for two sets of monolingual audiences, we erase not only bilingual language practices but bilingual audiences. Conversely, if we privilege bilingual audiences that look and sound like bilingual Chicano/a/x and Latinx children, we can "open up possibilities for bilingual writers" and we can prepare them to engage with the people who matter most to them [5]. By opening possibilities and building a platform for bilingual people to use their unique voice, it might encourage the individual to start creating engineering knowledge in different languages to maintain inclusivity among bilingual audiences.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 1826354. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation

References

[1] P. Levitt and B. N. Jaworsky, "Transnational migration studies: Past developments and future trends," *Annu. Rev. Sociol.*, vol. 33, pp. 129-156, 2007.

[2] P. Sánchez and G. S. Kasun, "Connecting Transnationalism to the Classroom and to Theories of Immigrant Student Adaptation," *Berkeley Review of Education*, vol. 3, no. 1, pp. 71-93, 2012.

[3] United States Department of Education. The condition of education: Racial/ethnic enrollment in public schools. [Online] Available: http://nces.ed.gov/programs/coe/indicator_cge.asp

[4] NGSS Lead States, *Next generation science standards : for states, by states*. Washington, District of Columbia: National Academies Press, 2013.

[5] R. Martínez, "Dual language education and the erasure of Chicanx, Latinx, and indigenous Mexican children: A call to re-imagine (and imagine beyond) bilingualism," *Texas Education Review*, vol. 5, no. 1, pp. 81-92, 2017.

[6] M. Tan, "Mathematics and science teachers' beliefs and practices regarding the teaching of language in content learning," *Language Teaching Research*, vol. 15, no. 3, pp. 325-342, 2011.

[7] National Academies of Sciences Engineering and Medicine, *English learners in STEM subjects: Transforming classrooms, schools, and lives*. Washington, D.C.: National Academies Press, 2018.

[8] G. Valdés, "Dual-language immersion programs: A cautionary note concerning the education of language-minority students," *Harvard Educational Review*, vol. 67, no. 3, pp. 391-430, 1997.

[9] E. Machado, R. Woodard, R. Coppola, and A. Vaughan, "Cultivating Opportunities for Young Adolescents to Use Multilingual and Multicultural Resources in School Writing," *Voices From the Middle*, vol. 26, no. 4, pp. 35-40, 2019.

[10] J. K. Adair, K. S.-S. Colegrove, and M. E. McManus, "How the Word Gap Argument Negatively Impacts Young Children of Latinx Immigrants' Conceptualizations of Learning," *Harvard Educational Review*, vol. 87, no. 3, pp. 309-334, 2017.

[11] B. Hart and T. R. Risley, "The early catastrophe: The 30 million word gap by age 3," *American educator*, vol. 27, no. 1, pp. 4-9, 2003.

[12] E. J. Johnson and A. C. Zentella, "Introducing the language gap," *International Multilingual Research Journal*, vol. 11, no. 1, pp. 1-4, 2017.

[13] F. A. Hrabowski and M. G. Sanders, "Increasing racial diversity in the teacher workforce: One university's approach," *The NEA Higher Education Journal: Thought & Action*, pp. 101–116, 2015.

[14] R. Otheguy, O. García, and W. Reid, "Clarifying translanguaging and deconstructing named languages: A perspective from linguistics," *Applied Linguistics Review*, vol. 6, no. 3, pp. 281-307, 2015.

[15] P. Velasco, and O. García, "Translanguaging and the writing of bilingual learners," *Bilingual Research Journal*, vol. 37, no. 1, pp. 6-23, 2014.

[16] N. González, L. C. Moll, and C. Amanti, *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. Mahwah, NJ: Lawrence Erlbaum, 2006.

[17] L. C. Moll, C. Amanti, D. Neff, and N. Gonzalez, "Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms," *Theory into practice*, vol. 31, no. 2, pp. 132-141, 1992.
[18] J. A. Mejia, "A sociocultural analysis of Latino high school students' funds of knowledge and implications for culturally responsive engineering education," PhD, Engineering Education Utah State University, Logan, UT, 2014.
[19] J. A. Mejia, A. A. Wilson, C. E. Hailey, I. M. Hasbun, and D. L. Householder, "Funds of knowledge in Hispanic students' communities and households that enhance engineering design thinking," in *American Society for Engineering Education Annual Conference*, Indianapolis, 2014, pp. 1-20
[20] A. Wilson-Lopez, J. A. Mejia, I. M. Hasbún, and G. S. Kasun, "Latina/o Adolescents' Funds of Knowledge Related to Engineering," *Journal of Engineering Education*, vol. 105, pp. 278-311, 2016.
[21] J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications, 2017.
[22] P. Auer, *Bilingual conversation*. John Benjamins Publishing, 1984.