Emergent Bilinguals’ Participation in Multilingual Engineering Learning Ecologies

Alberto Esquinca
San Diego State University, aesquinca@sdsu.edu

Maria Teresa de la Piedra
University of Texas at El Paso, mdelapiedra@utep.edu

Lidia Herrera-Rocha
University of Texas at El Paso, lherrera2@utep.edu

Follow this and additional works at: https://docs.lib.purdue.edu/jpeer

Part of the Bilingual, Multilingual, and Multicultural Education Commons, Engineering Education Commons, and the Language and Literacy Education Commons

Recommended Citation
https://doi.org/10.7771/2157-9288.1369

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.

This is an Open Access journal. This means that it uses a funding model that does not charge readers or their institutions for access. Readers may freely read, download, copy, distribute, print, search, or link to the full texts of articles. This journal is covered under the CC BY-NC-ND license.
Emergent Bilinguals’ Participation in Multilingual Engineering Learning Ecologies

Abstract
Students classified as English language learners (ELLs), many of whom are also Hispanic/Latine´/x, are at times excluded from opportunities to engage in engineering design experiences due to the emphasis on learning English. In dual language bilingual education, however, language policies that allow for the use and development of more than one language afford opportunities for ELLs that are not available in monolingual environments. We draw on a multilingual learning ecology theoretical framework to analyze data gathered from a two-year ethnographic study. During approximately 200 hours of field work, we gathered multiple forms of data through ethnographic methods, to include field notes from participant observation, interviews, photographs, and audio and video recordings. We show that participants enacted a multilingual learning ecology in which there was a space for both English and Spanish, but also hybrid language practices. Translanguaging, by either groups or individuals, mediated engineering design activities. The multilingual learning ecology also allowed students, many of whom were classified as ELLs, to agentively stretch their repertoire to engage in engineering biliteracy practices. These included identifying problems, proposing engineering solutions, building and testing a model, and communicating their findings.

Keywords
English language learners, disciplinary literacy, emergent bilinguals, Latinx/Hispanic

Document Type
Research Article

Título: La participación de bilingües emergentes en ecologías de aprendizaje multilingües en ingeniería

Alternate Abstract
Resumen
A menudo se tiende a excluir a los estudiantes clasificados por los sistemas educativos como aprendices de inglés (ELLs, por sus siglas en inglés), quienes incluyen un alto porcentaje de estudiantes Latiné/x o Hispanos, de oportunidades para participar en diseño de ingeniería porque se tiene la idea que deben primero aprender inglés. Sin embargo, vemos que en programas bilingües de doble inmersión (DLBE, por sus siglas en inglés) con políticas lingüísticas que permiten el uso y desarrollo de más de una lengua, se dan oportunidades para aprendices de inglés que no necesariamente existen en entornos monolingües. En este artículo, utilizamos el marco teórico de ecologías de aprendizaje multilingües para analizar datos recogidos en un estudio etnográfico de dos años. Recolectamos diversos tipos de datos durante 200 horas de trabajo de campo, que incluyen apuntes de observación, entrevistas, fotografías, y grabaciones de audio y vídeo. Demostramos que la ecología del aprendizaje multilingüe se realizó por las acciones de los participantes, ya que se abrió un espacio para el español y el inglés así como también prácticas lingüísticas híbridas. El translenguaje, ya sea verbalizado por individuos o por el colectivo, fue un mediador para la realización de actividades de diseño de ingeniería. La ecología del aprendizaje multilingüe también permitió que los estudiantes, muchos de ellos clasificados como aprendices de inglés, ejercieran su agencia para extender su repertorio con el fin de participar en prácticas de ingeniería biletradas. Estas actividades incluyeron proponer una solución a un problema de ingeniería, construir y realizar pruebas en un modelo, y comunicar sus hallazgos.
Alternate Keywords
Términos clave: aprendices de inglés; literacidades disciplinarias; bilingües emergentes; Latiné/x o Hispanos
Emergent Bilinguals’ Participation in Multilingual Engineering Learning Ecologies

Alberto Esquinca¹, María Teresa de la Piedra², and Lidia Herrera-Rocha²

¹San Diego State University
²The University of Texas at El Paso

Abstract

Students classified as English language learners (ELLs), many of whom are also Hispanic/Latino/x, are at times excluded from opportunities to engage in engineering design experiences due to the emphasis on learning English. In dual language bilingual education, however, language policies that allow for the use and development of more than one language afford opportunities for ELLs that are not available in monolingual environments. We draw on a multilingual learning ecology theoretical framework to analyze data gathered from a two-year ethnographic study. During approximately 200 hours of field work, we gathered multiple forms of data through ethnographic methods, to include field notes from participant observation, interviews, photographs, and audio and video recordings. We show that participants enacted a multilingual learning ecology in which there was a space for both English and Spanish, but also hybrid language practices. Translanguaging, by either groups or individuals, mediated engineering design activities. The multilingual learning ecology also allowed students, many of whom were classified as ELLs, to agentively stretch their repertoire to engage in engineering biliteracy practices. These included identifying problems, proposing engineering solutions, building and testing a model, and communicating their findings.

Keywords: English language learners, disciplinary literacy, emergent bilinguals, Latinx/Hispanic

Resumen

A menudo se tiende a excluir a los estudiantes clasificados por los sistemas educativos como aprendices de inglés (ELLs, por sus siglas en inglés), quienes incluyen un alto porcentaje de estudiantes Latino/x o Hispanos, de oportunidades para participar en diseño de ingeniería porque se tiene la idea que deben primero aprender inglés. Sin embargo, vemos que en programas bilingües de doble inmersión (DLBE, por sus siglas en inglés) con políticas lingüísticas que permiten el uso y desarrollo de más de una lengua, se dan oportunidades para aprendices de inglés que no necesariamente existen en entornos monolingües. En este artículo, utilizamos el marco teórico de ecologías de aprendizaje multilingües para analizar datos recogidos en un estudio etnográfico de dos años. Recolectamos diversos tipos de datos durante 200 horas de trabajo de campo, que incluyen apuntes de observación, entrevistas, fotografías, y grabaciones de audio y video. Demostramos que la ecología del aprendizaje multilingüe se realizó por las acciones de los participantes, ya que se abrió un espacio para el español y el inglés así como también prácticas lingüísticas híbridas. El translenguaje, ya sea verbalizado por individuos o por...
el colectivo, fue un mediador para la realización de actividades de diseño de ingeniería. La ecología del aprendizaje multilingüe también permitió que los estudiantes, muchos de ellos clasificados como aprendices de inglés, ejercieran su agencia para extender su repertorio con el fin de participar en prácticas de ingeniería biliteradas. Estas actividades incluyeron proponer una solución a un problema de ingeniería, construir y realizar pruebas en un modelo, y comunicar los hallazgos.

**Términos clave:** Aprendices de inglés, literacidades disciplinarias, bilingües emergentes, Latín/x o Hispanos

### Introduction

Students labeled as “English language learners” (ELLs) are, all too often, denied equitable opportunities to participate in engineering learning experiences. Starting at the policy level, we observe that, although English is not the official language of the United States, de facto language policies (Shohamy, 2006) have historically created a system of exclusion. Institutions that serve students labeled as ELLs are then tasked with ensuring that they learn English, channeling students with that stigmatizing label into spaces that seek to relabel them. These students are, thus, often excluded from opportunities to engage in meaningful enrichment learning opportunities, including open-ended activities that encourage agentive learning (Adair et al., 2017), or, for secondary learners, Advanced Placement courses (Mortimer & Dolsa, 2020). Specifically, students labeled as ELLs may be denied opportunities to engage in challenging science and engineering (S&E) learning, due to the misperception that English is a prerequisite to engage in these opportunities (National Academies of Sciences, Engineering, and Medicine, 2018). Considering that, according to the National Center for Education Statistics (2018), 77% students labeled as ELL are also Latinx, these policies of ELL exclusion disproportionately impact Latinx communities, one of the groups whose participation in S&E is most dismal.

Although the majority of students labeled as ELL are denied access to develop bilingualism and biliteracy (Menken & Kley, 2010), some do receive access to high-quality bilingual education programs, such as dual language bilingual education (DLBE). In these programs, learners’ existing assets are leveraged to further develop bilingualism and biliteracy while simultaneously participating in S&E learning experiences. In these cases, bilingual teachers are tasked with integrating biliteracy into S&E instruction so that in every lesson students learn content and literacy. To acknowledge that learners are becoming bilingual and biliterate in DLBE, we use the term *emergent bilinguals* (EBs) instead of ELLs. Further, we recognize that EBs engage in dynamic, hybrid language practices as they build their linguistic repertoire. These practices include, for example, shuttling back and forth between their languages or learning early literacy skills in their primary language and transferring that knowledge to their second language. While these hybrid practices may be seen from a deficit perspective, we consider them to be examples of the community cultural wealth (CCW) (Yosso, 2005) of Latinx communities.

**DLBE** potentially affords the creation of multilingual learning ecologies. In these spaces, EBs’ CCW (including bilingualism and biliteracy) is valued. What that means is that they can leverage their CCW to develop powerful discourses, including engineering biliteracy disciplinary practices. Teachers play a key role in designing multilingual learning ecologies (Esquinca et al., 2021). Students, too, play a key, agentive role in creating such a learning ecology, as we show in this ethnographic study of a DLBE program set on the USA–Mexico border. We illustrate the affordances for expansive learning, which refers to “powerful forms of literacy and identities as language users and meaning-makers” (Gutiérrez et al., 2011, p. 236) in DLBE classrooms. We answer the question: What are the affordances in the hybrid, multilingual learning ecology of a DLBE classroom to develop engineering biliteracy disciplinary practices? We show the affordances in a fourth-grade DLBE classroom, as bilingual learners engaged in multilingual, inquiry-based engineering design activities. Namely they leveraged their biliteracy practices and translanguaging to develop engineering disciplinary biliteracy practices, including identifying an engineering problem, testing materials, building and testing a model, determining if the model was successful, and presenting their findings.

According to the National Academies of Sciences, Engineering, and Medicine (2018, p. 72), “to date, no studies of K-12 classroom engineering specifically focus on Els.” In this article, working from an asset-based perspective, we address this void and show what EB students bring to engineering learning. Drawing on a learning ecology perspective, we show how DLBE teachers create ecologies for equitable participation “organized around expansive forms of learning” (Gutiérrez et al., 2011, p. 236). We show how the DLBE space afforded them the opportunity to participate in a multilingual space for S&E learning and agentively stretched their repertoire to add engineering disciplinary biliteracy practices.

---

1In this article we use the gender-neutral term Latinx instead of the more common term Latinx.
**Theoretical Perspective**

We draw on the concept of learning ecologies, which is based on sociocultural (Cole, 1998; Gutiérrez et al., 2009; Lave & Wenger, 1991; Rogoff, 2003; Vygotsky, 1978) and ecological theoretical frameworks (Barron, 2006; Bronfenbrenner, 1979). From this perspective, complex, multiple factors (social, historical, and cultural factors) (Engeström, 1999) shape collective learning activity. Ecological theories of learning pay attention to the situation in which learning occurs and seek to understand learning in cultural and historical contexts rather than learning as a purely individual, cognitive activity. “A sociocultural theory of the mind is primarily concerned with distributed cognition and consciousness as mediated through social interaction and cultural artifacts” (Martín-Beltrán, 2010, p. 255). System-wide, collective activity, not individual action, is the unit of analysis.

Distributed cognition also allows for possibilities of agentive action. The concept of sociocultural affordances refers to possibilities of action that are offered in a learning ecology, which accounts for agency in learning ecologies, as individuals and collectives interact in particular environments (Pyysäläinen, 2021). As Gutiérrez and Calabrese Barton (2015) argue, there is an interplay between structure and agency. “Individual and collective action is enabled and constrained by the social structures-in-motion, both in-the-moment and over time” (p. 575). As ecologies occur in context, learning activity is mediated by cultural tools.

One of the key mediating cultural tools is language, and its potential is enabled or constrained by historically informed, ideologically driven, language education policies, at the micro and mezzo levels (Shohamy, 2006). DLBE program policies create the space for delivering instruction in more than one language. Depending on various contexts where DLBE is implemented, the speakers they serve, and the amount of time destined to the languages involved, configurations vary. Additive ideologies of bilingualism usually guide instruction with the purpose of language and biliteracy development, academic achievement, and sociocultural understanding (Howard et al., 2018). Additional guiding principles of DLBE include comprehensible input, oral language and biliteracy development, language and content integration, and heterogeneous grouping strategies (Howard et al., 2018).

Local relationships, including between teachers, between teachers and students, and among students, shape learning ecologies. For instance, many learners in DLBE classrooms are students classified as ELLs. Their experiences are shaped by policies and practices for language-minoritized students. DLBE is a program option built on a foundation of striving for equitable participation of students classified as ELLs, i.e., language-minoritized students (Flores & García, 2017).

In DLBE classrooms, language is “as a medium for learning content and content as a resource for learning and improving language” (Stoller, 2002, p. 109). Bi-/multilingual learning ecologies are created as a matter of policy. DLBE teachers are trained to identify and draw on the existing cultural and linguistic repertoires that minoritized students bring to learning activities, what Gutiérrez and Rogoff (2003) refer to as repertoires of practice. DLBE teachers can design ecologies that promote interaction and dialogue in which students access cultural tools that mediate learning, including language (Ochs & Schieffelin, 1984; Heath, 1983). Such learning ecologies can potentially apprentice learners to use various modes of discourse. In these ecologies, students transact agentively in a dynamic and agentive relationship with their learning environment (Gutiérrez & Calabrese Barton, 2015; Pyysäläinen, 2021).

A multilingual learning ecology affords EBs opportunities to stretch repertoire of practices as they participate in engineering design activities, if and when we consider “the cultural contexts, assets, and experiences that students bring to engaging engineering design” (Calabrese Barton et al., 2021, p. 90). Engineering education that considers the particular assets of EBs’ repertoire, including their languaging practices, challenges reductive notions of engineering education as monolingual learning ecologies. These ecologies afford students to stretch their repertoires to add engineering disciplinary literacy practices.

Disciplinary literacy practices refer to the discipline-specific ways of using language, texts, and reading, writing, and interpreting texts (Moje, 2008; Shanahan & Shanahan, 2008, 2012, 2014). Engineering disciplinary literacy practices include solving problems, creating and evaluating texts, and designing/modifying solutions. When students engage in these practices, they are provided meaningful opportunities to think, talk, and write like engineers (Gee, 1996). The Next Generation Science Standards (National Research Council, 2012) emphasize the importance of connecting S&E to diverse students’ interests and home languages (Rodriguez & Berryman, 2002). Research on engineering disciplinary literacies, particularly in contexts that promote biliteracy practices, can provide educators with the necessary tools to engage in this type of critical and transformative way of thinking through problem-solving designs.

**Literature Review**

**Engineering (Bi)Literacy Disciplinary Practices**

We use the term engineering disciplinary biliteracy practices (Esquinca et al., 2021) to specifically address EBs’ language practices, which span languages (translanguaging) and are multimodal and multilingual (García & Wei, 2014). We use the term engineering disciplinary biliteracy practices (Esquinca et al., 2021) to specifically address the monolingual bias that leads
educators to assume that “academic” or disciplinary literacies are in English. Indeed, in our work, we problematize this assumption as well as the label that focuses on what learners lack. The term “ELL” does not acknowledge that in bilingual classroom settings there are students who are learning other languages besides English, just as many of our participants in this study. When conducting our own literature review, we found a few studies on the topic that focused on ELLs’ engagement in engineering design activity (McVee et al., 2017), ELLs’ experience with designs, models, materials, and interacting with others (Yocom de Romero et al., 2006), and the use of stories in engineering curriculum with ELLs (Cunningham & Lachapelle, 2014). As bilingual education scholars, we center our gaze on EBs’ experience in multilingual engineering classroom ecologies, where they agentively leverage their assets to participate in the learning process.

While research specifically on engineering disciplinary biliteracy practices is scarce, the evidence points to its potential positive outcome on students’ academic and linguistic growth. Esquinca et al. (2021) describe how, in a DLBE classroom where students were learning in and through the engineering design process, teachers planned instruction so that students’ use of their entire linguistic repertoire was an asset for them as they expanded their repertoire. Teachers led students to expand their repertoire, develop content knowledge, and engage in engineering biliteracy practices as they designed earthquake technologies and efficient solar homes through translanguaging practices, discussions, and analysis of texts in a dual language context. Wilson-Lopez and Minichiello (2017) also emphasize the positive impact engineering disciplinary literacies can provide for historically underserved communities. They describe how middle school students redesigned their school parking lot by engaging in engineering literacy practices. By analyzing texts, including Spanish and English parent interviews, an aerial picture of the parking lot, data of cars entering and exiting per day, parking lot regulations, and cost estates, they defined their problem—the school parking lot was unsafe and needed a safer design and remodeling. Students created evidence-based arguments to solve real-world, relevant problems. Wilson-Lopez and Minichiello (2017) suggest that rigorous interpretations of multiple sources of information to derive solutions can be impactful when the problem is relevant to their lives and in classroom contexts that foreground diverse learners’ home languages.

**DLBE Bi-/Multilingual Learning Ecologies**

We distinguish between monolingual and bi-/multilingual learning ecologies or what García (2011) refers to as monoglossic and heteroglossic ideological contexts. A bi-/multilingual learning ecological view highlights the crucial importance of sociocultural contexts for learning, including those that explain the affordances of learning ecologies in multilingual, multicultural contexts (Gutiérrez et al., 2011). In contrast to monolingual learning ecologies, DLBE potentially affords the creation of hybrid, bi-/multilingual learning ecologies. Such ecologies may create opportunities for students to use the full range of meaning-making (or semiotic) resources in order to learn meaningfully. A bi-/multilingual learning ecology is one in which learners are not hobbled by participating in only one of their languages or meaning-making systems, but have a vast array of tools at their disposal, including hybrid languaging practices. These ecologies may be particularly important for minoritized students, e.g., working-class Latiné students. They potentially allow children to develop languaging, literacies, and identities as learners. Through micro policies about expected language use teachers can communicate the relative value of different named languages in the classroom space. Whereas in monolingual learning ecologies, school and district policies dictate that the majority language, e.g., English in the USA, is the expected language of school, in multilingual spaces, there are policies that allow for more than one language to be used. In dual language classrooms, for instance, learning ecologies’ two named languages are usually used and developed in instruction.

The identifying language policy in a dual language learning ecology is the language policy known as language separation (Howard et al., 2018). This policy is meant to create equal instructional time for at least two languages, one of which is the majority language. To create equal time, a language separation policy dictates that both languages should be used the same amount of time. Schools may then create micro policies on how to separate language, either by day or school subject. For instance, on Spanish day, materials and instruction will be provided in Spanish. Students are also asked to participate in that language. In some classrooms, language is not separated by day, but it is separated by school subject. Like any policy, language separation policies are based on ideologies (Shohamy, 2006; Spolsky, 2004). In this case, the ideology that languages must be kept separate may be based on language purism (Spolsky, 2004; Woolard, 1998). These policies may be overly restrictive, and they may be based on deficit linguistic orientations (Martínez et al., 2015; Menken & Avni, 2017). In addition, recently, DLBE spaces are becoming gentrified—with enrollment slots for working-class Latiné becoming reduced (Freire & Alemany, 2021; Valdez et al., 2016). In addition, DLBE programs “overwhelmingly favor compartmentalized, monolingual, written, decontextualized language and literacy practices” (Hornberger & Link, 2012, p. 245). There is an urgent need to explicitly focus on critical consciousness (Cervantes-Soon et al., 2017; Palmer et al., 2019) in DLBE.

Furthermore, larger social, political, and historical forces (e.g., the history of colonization, educational and linguistic policies) create language ideologies that place monolingualism over multilingualism hierarchically. In turn, these ideologies play a key important role in how, when, and with whom speakers use their language repertoires. Restrictive monoglossic ideologies of linguistic purity characterize translanguaging of borderland bilinguals as so-called “incorrect Spanish” or
so-called “incorrect English.” These ideologies may go on to form the basis of language policies (Shohamy, 2006; Spolsky, 2004). From a translanguaging perspective, speakers have access to these features but have learned that, for particular social situations, these features and named codes are to be kept separately. The theory of translanguaging, rather than focusing on the “code” emphasizes highlighting speakers’ practices in the midst of social activity. In the following section, we provide a brief overview of relevant translanguaging research.

Translanguaging in Multilingual Learning Ecologies

Bilingual speakers use language dynamically: they switch, mix (Mendoza-Denton, 1999; Nilep, 2006), or mesh codes (Canagarajah, 2013). Rather than understand these language practices as problems, scholars have argued that these practices are part of the cultural wealth of minoritized communities (Yosso, 2005). Others have argued that the stigmatization of these language practices is rooted in ideologies of linguistic purism (Spolsky, 2004; Woolard, 1998) and a colonialist logic (Pennycook, 2021; Piller, 2016).

In broad terms, translanguaging (García & Wei, 2014; Sánchez & García, 2022) refers to the “multiple discursive practices in which bilinguals engage in order to make sense of their bilingual worlds” (García, 2011, p. 45). Similarly, Pennycook (2017) describes translanguaging as bilinguals’ use of their multiple semiotic repertoires as part of their “assemblage.” More specifically, it includes language practices that range from inter-sentential code switching to language switches between people. A common misconception is that translanguaging is a synonym for code switching, which typically refers to an individual’s intra-sentential switch. When a speaker starts a sentence in English y acaba en español (Poplack, 1980). However, from an ecological perspective, translanguaging is a practice that can characterize communicative exchanges between people rather than in a single individual. Translanguaging can include interactive practices among groups of people, such as when a bilingual speaker interacts in English and a bilingual conversational partner responds in Spanish. These interactions occur very frequently in multigenerational bilingual homes when, for example, an adult speaks in one language and a child answers in another language. Another example is when bilingual speakers talk about a text they read or they are authoring in Spanish and they write it in English (Bartlett & García, 2011). Furthermore, translanguaging encompasses meaning-making across modes of semiotic representation (different sign systems) (Kress, 2010). These include verbal linguistic features but also multimodal signs as part of their semiotic repertoires, such as drawings, designs, videos, PowerPoint presentation, the speakers’ bodies, the arrangement of bodies and things in the space of interaction at their disposal. In this article, we also use the term “multilingual” to acknowledge that bilinguals draw on a vast repertoire of semiotic resources that include, but are not limited to, named languages (Spanish, English). For instance, an EB may draw on multiple varieties of English or Spanish including Chicano English, Black English, or regional varieties of Spanish in a single turn of talk. These varieties are sometimes excluded from understanding of “proper” or “school-like” Spanish or English. Bilinguals switch between several “named” codes (Flores & Rosa, 2015; Rosa, 2019) and draw from features of these socially constructed languages as they need and according to their purposes, audience, and specific situation and local context. From our perspective, they are part of a legitimate multilingual repertoire of languaging practices.

Beyond the linguistic issues, scholars have argued that translanguaging has transformative potential when communities can leverage it to reconfigure power, disrupt established knowledge, develop Latiné students’ critical consciousness, and humanize education for Latiné students (Sánchez & García, 2022). Thus, in our research context, the USA–Mexico border, the historical and intense contact between Spanish and English (Mendoza-Denton & Gordon, 2011) is a particular ethnolinguistic context that in itself questions the language separation proposed by schools. This is manifest in the myriad ways that border residents and transfronterizers (a gender-neutral term for border crossers) communicate and make meaning (de la Piedra et al., 2018), but also in how Latina teachers transform these spaces within the sometimes oppressive context of DLBE (de la Piedra & Esquinca, 2021).

This article is part of a larger study (Esquinca et al., 2018, 2021; Esquinca & Herrera-Rocha, 2022). In this article, we analyze the use of translanguaging in the different contextual layers of the interactions occurring in the learning ecologies of a dual language classroom. We pay attention to how students used translanguaging during organized instruction that was to be rendered in just one code, either Spanish or English. We also pay attention to the translanguaging practices that learners engaged in as they participated in engineering units bilingually. In the context of DLBE, the program assigned “Spanish days” and “English days” for instruction, and students learned language features of the named languages, which they added to their linguistic repertoires. They used these features agentively—in ways that made sense to them—meaning that students may or may not be strictly following the language separation policy. We conceptualize these practices as translanguaging, even if the institutional context is organized for language separation.

Methodology

This ethnographic study began in 2015 at a semirural district school (“Ramos Elementary”) located on the USA–Mexico border. Ramos served a population of 600 students, 84% of whom were Latiné and 30% of whom were labeled by the state
as “Limited English Proficient” (LEP)\(^2\)—a problematic term we use only in quotations. We used ethnographic methods to understand the lives of participants through an extended period of time (Emerson et al., 2011). As ethnographic researchers, we immersed ourselves in the daily lives and practices of the site, building rapport with participants. As bilingualism/biliteracy scholars, we specifically drew on linguistic ethnographic perspective (Heath & Street, 2008).

We chose Ramos because it had recently been designated as a “STEM-focused school.” It had started to use engineering design using engineering kits or modules, and it had a dual-language strand. The commercially available kits were purchased through a grant (authors were not involved in the purchase). They were each broken up into twelve, 50-minute lessons that applied principles of engineering design, i.e., the engineering design cycle. In one module, students were asked to address the real-life problem of keeping a solar house warm in the winter using only the sun’s energy. In another module, students determined the best technology to keep a tower steady during an earthquake. The grant arranged for teachers to be introduced to the kits. We did not observe any training specifically for DLBE teachers. As bilingual educators interested in researching S&E learning, especially among immigrant/Latinx students, we considered this combination to be an ideal research site in which to begin a project.

We collected data for two years (2016–2018) and completed approximately 200 hours of fieldwork in fourth-grade DLBE classrooms at Ramos. Our data collection included various sources and data collection methods: field notes from participant observation (including photos, audio, video, and artifacts) and semi-structured teacher interviews. As part of participant observation, we wrote detailed field notes (Frank, 1999). Our field notes focused especially on participants’ bilingualism and biliteracy practices, as well as teachers’ pedagogical practices. Since we were interested in the learning ecology of the dual language classroom, we documented social interactions during engineering teaching and learning.

To collect interview data, we interviewed teachers using a semi-structured protocol. We sought to understand teachers’ perspectives on the experience of teaching engineering in a dual language context. For instance, we asked questions like: “What opportunities for language development do you see in the engineering modules?”

**Participants.** We recruited three teachers and 61 student participants for the study. The school offered a dual language (DL) program and an English monolingual program (sometimes referred to as “mainstream”). Most students labeled by the state as “LEP” were enrolled in the DL program as a form of English language support—except for children whose parents refused such support. In addition, DL programs enroll both students learning the majority language (English) and students learning the “minority language,” in this case Spanish. Our participants included students who were not labeled as “LEP” but were Spanish learners. In terms of ethnicity, most participants were Mexican-origin Latinx, mirroring the demographics of the school. Table 1 summarizes the information on participants.

In order to answer our research question, we focused our attention on social interaction in the context of engineering design activities. We coded data (interview transcripts, field notes) and analyzed data cyclically, starting with initial coding. Based on our initial codes, we selected video excerpts to transcribe and code. We conducted team meetings for focused coding (Charmaz, 2014). We coded data regarding (1) language and (bi)literacy use, (2) teaching practices, and (3) student learning of engineering during whole-group, small-group, and teacher-to-student activities. Some of the relevant categories to emerge during data analysis meetings include engineering discourse practices, use of vernacular language, bilingual languaging (translanguaging), student engagement, practices to promote engagement, and engineering identities. In addition, ethnographic research is a triangulated process (Denzin, 2017). We identified the categories listed above in interview data, fieldnotes, and video, as well as across participants. Through multiple methods of data collection and resultant sources of data, we were able to form a meaningful picture of the multilingual learning ecology at Ramos. As we had written and coded field notes, our analysis of video data was informed by our process of open coding.

Further, we used criteria of trustworthiness of our research practice along with a reflective process. As proposed by Mishler (2010), we evaluated the process we took to get to our claims and the trustworthiness of our data and interpretations. Maxwell (2010) warns us against these threats to the validity of our qualitative conclusions. We followed Charmaz’s (2014) recommendations to make sure of the credibility of our research. We were intimately familiar with the setting during the two years of fieldwork, which necessitates a process of gaining the trust of our participants and allows us to become experts in the topic. We had in-depth observational data, including video data to support the claims we make. In order to avoid selecting data that fit our preconceived notions, we engaged in individual analysis of the data. Later, we had analysis sessions where we discussed our individual interpretations. We searched for evidence that could challenge our interpretations in the data. The data presented in this article are the quality of evidence that shows trustworthiness. In addition, we were aware of our subjectivities and positionalities (possible “biases”) and discussed in our team as to how to deal with them, in both data collection procedures and interpretation. Finally, we acknowledge that criteria of reliability are not relevant in this paradigm, and we are not “concerned with eliminating variance between researchers, in the values

\(^2\)Recently, the state has begun to use the “emergent bilingual” nomenclature. However, it is still unclear whether covert and overt policies will also change.
and expectations” (Maxwell, 2010, p. 281). As part of our methodology, we present our positionalities as researchers, so that readers may draw their own conclusions regarding our subjectivities. As for our positionality as Latine/x bilingual teacher educators, we approach the study of engineering disciplinary literacies through a critical ethnographic lens. We prepare (mostly) Latina bilingual teachers who have historically been positioned from a deficit perspective. They usually go on to teach students classified by school systems as ELLs or even “LEP.” As qualitative researchers, we were engaged in every aspect of this study, and our intention was to be reflexive throughout the process by paying conscious attention to our positionality. The first author is a Mexican-born immigrant who learned English as a second language. A former transfronterizo student, he grew up and spent most of his life in the border community in which this study is set. The second author is a Peruvian educational anthropologist who lives on the USA side of the Mexico–USA border. She is bilingual, an immigrant to the USA, and she is the mother of two Latinx children who attended dual language and ESL education in the USA. The third author is the child of Mexican-American immigrant parents living in the USA. She grew up labeled as an English learner for her “limited” abilities in the mainstream language. Her experiences as a student and as a teacher in a bilingual program have led her to engage in research focused on EBs and the potential for meaningful, equitable learning environments. Our positionalities shaped how we designed and conducted this study.

Findings

Hybrid, Multilingual Spaces in Dual Language Classrooms

As noted above, learning ecologies are shaped by historical, social, and cultural factors that afford actors language practices. The learning ecology at Ramos was shaped from local, district, and state language policies (mezzo level). Despite the stated (“official”) policy on language separation at the mezzo level, there was a de facto (Shohamy, 2006) micro-level policy enacted in the classroom. It afforded actors for flexibility, and it lent itself for various forms of translanguaging in the pursuit of engineering learning practices.

As micro-level policy makers, two focal teachers for this article, Ms. Guevara and Ms. Galván, were afforded the flexibility to develop micro-level policies that afforded the creation of a multilingual ecology. The multilingual learning ecology we refer to in this article developed over time. Micro-level policies in the first year of the project consisted of doing engineering design activities in English. In interviews, Ms. Guevara stated that she “felt insecure [about engineering],” and she partnered with Ms. Aguilar (see Table 1). She noticed that students labeled as ELLs in her class “hesitated when they were with the big group of monolingual [English] students because they feel inferior whenever they need to express themselves because they’re embarrassed by how they’re going to sound.” In the second year, she had the opportunity to have more space for doing engineering in both languages. “I think it helps the kids more. I should have done it in Spanish last year, they would have gotten it better, understood more. They would have felt more confident.” In the following section, we show how teachers created a multilingual learning ecology.

Language Separation—Switching Language by Day

A mezzo-level policy for separating language by day, which came from the district office, was followed by our focal teachers. This meant that whatever subject was taught that day, instruction was provided in one of two languages, Spanish or English. Implementing the policy meant that two teachers were hired to provide instruction, Ms. Garza in Spanish and Ms. Guevara in English. The languages were switched by day, and the lead teacher of the day would provide instruction to the whole class in that language.

Another part of implementing the policy was the practice of identifying students by language dominance. Teachers told us during interviews that this policy allowed teachers to create small, heterogeneous groups based on language dominance, i.e., “Spanish-dominant,” “English-dominant,” “balanced bilingual.” The idea behind this practice was that students could

<table>
<thead>
<tr>
<th>Academic year</th>
<th>Teacher</th>
<th>Language</th>
<th>Students</th>
<th>Program</th>
<th>Module</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ms. Aguilar</td>
<td>English</td>
<td>21 (0 LEP)</td>
<td>Monolingual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ms. Galvan</td>
<td>Spanish</td>
<td></td>
<td>Monolingual</td>
<td>Technologies</td>
</tr>
</tbody>
</table>
help each other to get through the engineering tasks, such as by translating for each other or helping each other say or write something in the language of the day.

In this classroom, the language separation policy was especially followed in whole group instruction. The policy was referenced and enforced when, during whole-group instruction, teachers would ask students who used the unassigned language to repeat something in the language of the day ("¿Cómo se dice en español?" or "No te entiendo. ¿Lo puedes repetir?"). Students who were not dominant in the language would still be able to get assistance from their peers, as shown in the examples we share in the next section.

In small-group interaction, teachers expected that students would work on engineering design practices using the language of the day. However, we observed that small groups agentively developed their own micro-policies and practices. In other words, students themselves were agents within the multilingual learning ecology using their hybrid languaging practices created an additional layer of micro-policies. The teachers, in acknowledging students’ practices, allowed students flexibility to communicate using their full linguistic repertoire, including their translanguaging practices. Together, teachers and students enacted policies that created a multilingual learning ecology. As we carried out ethnographic fieldwork, teachers told us that these practices (stick to the language of the day and flexible languaging) made sense to them.

Another example of micro-level policies within the dual language learning ecology that allowed for multilingualism was observed in how teaching materials (including engineering kits) were used. The district policy meant that materials were to be provided in the language of the day. However, a de facto policy was implemented by our focal teachers. The engineering design curriculum materials were available in both languages, including worksheets in both languages. When the teachers created packets for students, they decided to provide worksheets only in one of the languages. Thus, instruction could be in Spanish, but the students completed worksheets in the other language. This example of translanguaging—talking about a topic in one language and writing in another—was a very productive and normalized practice. From a strictly separatist perspective, it could be said that the teachers were not implementing the district policy because they were not providing all instruction and materials in the language of the day. However, from a multilingual learning ecology perspective, the teachers were creating an ecology that lent itself to hybrid languaging. Teachers explained that this was an efficient way to handle materials.

As previously stated, in small groups, students would freely move between languages to translanguage meaningfully. For example, the following excerpt presents a typical interaction in small groups. In addition, it illustrates dialogue around a collective learning activity—discussing to define an engineering problem. That day, the teacher had started the lesson, which fell on a “Spanish day,” by presenting a short whole-group interactive presentation about key notions that students needed to understand to fill out the worksheets in preparation for their modeling of their solar houses at the end of that week. She explained, for example, what radiant solar energy was, its importance to heat a solar house, the process of heating the house, the considerations of where to locate the windows, and how to select the flooring. In the interactive whole-group presentation, students participated by offering explanations of engineering concepts in their own words. For example, when the teacher asked for a definition of “absorber,” Martha stated “Es como si fuera una esponja que absorbe toda el agua.” After this whole-group interaction, students were to work in their “grupos de ingenieros,” in a small group (field notes 1/23/18) with the purposes of responding to three questions posed in the worksheets in Spanish. The teacher approached a group and guided them by asking questions and reassuring that their responses were adequate to write in the worksheet. The following interaction shows how engaging in defining a problem—an engineering disciplinary practice—leads to a discussion about radiant energy that is enriched by translanguaging.

---

Ms. Galván: What is radiant energy?
Denise: It’s the energy that comes out of the sun
Ms. G: Very good, write that “it’s the energy that comes from the sun”
[Meaning that this is what D should write in her worksheet]
Jose: Light that comes from the sun. D, fix that
[D pays attention and corrects the sentence]
Alicia: Wait, wait! How do you spell proviene?
Jose: [Spelling in English] P-R-O… [Meanwhile students continue writing in their individual worksheets and move to another question on light reflection]
Denise: I say that reflection is when...
Jose: Bounce, it goes from here to there
Denise: It’s like jumping
Jose: It’s like this [makes a hand gesture to show how light bounces]
The above example (transcribed from video data) shows that the learning ecology affords the opportunity for meaningful interaction about discussing an engineering problem through translanguaging. In the short excerpt, there is an example of Ms. G asking Denise to complete the worksheet (in English), where she might have asked her to complete “la hoja de trabajo.” Second, there is an example of a girl, Alicia, asking for assistance to understand the meaning of the word proviene. Though she only asked for assistance in spelling the word, Jose and Denise provided on-the-spot assistance on the meaning of the word. In addition, the example shows how Jose drew on gestural mode to make the meaning of the word clear. Through the work of all participants in the learning ecology, the day’s lesson continued in the language of the day.

**Translanguaging to Build Engineering Understanding Across Time**

From a learning ecology perspective, translanguaging can characterize interactions spanning activities across time. In our video and observational data, we observed that switching between languages (Spanish day/English day) across the span of the study unit generated a learning ecology that permitted students to engage in engineering practices (at the same time expanding their linguistic repertoires), and thus construct understanding across languages. What they learned in Spanish transferred so that they continued learning about the same topic in English. Activities that were started on English day could be finished on Spanish day without the need for re-teaching. Teacher interviews confirmed that teachers observed similar results of translanguaging practices.

Another affordance of the hybrid, multilingual space of the dual language classroom was that students could engage in engineering practices in two languages, across lessons, and across time (i.e., activities in which they participated on Spanish days were continued on English days). From an ecological perspective, the activities and practices are the unit of analysis, and these activities are carried out in the language of the day.

An example of these affordances comes from a 12-day engineering design unit on designing a solar house, summarized in Table 2. On the second day, students tested building materials on an English day in order to choose the flooring materials that would best keep a house warm in the winter. Their tests showed that, out of brick, light tile, and slate, brick was the best flooring material because it absorbed the sun’s heat the best. The next day, a Spanish day, the teacher began by reminding students that they had tested the materials and the results of the test. In doing so, she activated students’ prior knowledge about engineering and, simultaneously, created a bridge between material learned in English and in Spanish.

As the class engaged in engineering practices, they went through the engineering design cycle. By the seventh day of the unit, teams started to plan their design of a model. Teams proposed a design, which included choosing the number of windows and their location on the model, as well as flooring type. They had to consider constraints, including the budget, which had to be under a set amount.

One of the teams, like all the others, participated in testing flooring materials (an engineering disciplinary practice) and knew the results of the test, which indicated that brick was the best flooring material. As they continued their design proposal (on a Spanish day), we asked them to justify their design choices. In their explanation, they had relied on their experiential knowledge about light tile. In one observation, Martha noted that at her grandmother’s house there was light tile flooring. The transcription of a selection of the video follows.

| Mayte: Y el piso ¿cómo va a ser? | Mayte: And what will the flooring be? |
| Gastón, Jesse y Martha: Light tile | Gastón, Jesse and Martha: Light tile |
| Mayte: Light tile. ¿Y por qué decidieron eso? | Mayte: Light tile. And why did you decide that? |
| Martha: [levantando la mano] Yo puedo [M: sí] Porque en el experimento que la otra vez hicimos con conductor y aislante y probaron que la piedra o sea el brick agarra el calor pero luego luego que lo tocas se [gesto] se enfria entonces esta…slate también es una piedra entonces vamos a seguir light tile porque es ah ¿cómo se dice? [Jesse: ce…cerámica?] ceramic [M: cerámica] y así agarra el calor por eso pensamos en… | Martha: I can [answer]. Because in the experiment that we made the other time brick was the best but before that we did with conductor and insulator and they proved that the stone, that is, the brick captures the heat but as soon as you touch it, it cools down then we…slate is also a stone so we went with light tile because it’s ah…how do you say it? [Jesse: Are…ceramic?] Ceramic [Mayte: ceramic] and so it catches the heat, that’s why we think about… |
| Mayte: Y queda el calor en la cerámica más tiempo | Mayte: And the heat remains in the ceramic for longer |
| Jesse: Aunque tarda para calentarse | Jesse: Although it takes time to warm up |
| Martha: Se queda mucho el calor | Martha: It maintains a lot of heat |
| Jesse: Sí, sí, aha | Jesse: Yes, yes, aha |
| Martha: Como si cierras la cortina se queda el calor | Martha: Like, when you close the curtain, the heat remains |

Taken together, these findings suggest that hybrid, multilingual spaces afford the creation of an ecology where EB students can participate in meaningful engineering design activities. In these activities, students go through the engineering design cycle, use the disciplinary artifacts and tools, and engage in engineering disciplinary practices. For the solar house...
unit, they tested building materials, proposed a model design, created a budget, built a model, tested the model, and communicated their findings. Hybrid translanguaging biliteracy practices, including by individuals and by groups and in single communicative events and across communicative events, sustained the knowledge construction across time and made engineering learning possible. In the following section, we further develop the theme of engineering disciplinary biliteracy practices.

Engineering Disciplinary Biliteracy Practices

In this section we provide representative examples of how engineering disciplinary biliteracy practices span languages. We observed numerous instances of students agentively stretching their repertoire of practices to “ratchet up expertise and agentic identities” (Gutiérrez et al., 2011, p. 259).

Day 3 (1/23/18), after students had tested building materials, was a “Spanish day,” and Ms. Galván had developed a lesson in which students reviewed vocabulary in preparation for the following lessons. She asked students to define key vocabulary terms in their own words. The excerpt shows how the teacher supported students to define terms and, at the same time, understand the engineering problem in detail. This collective action acted as a scaffold in order to later engage in further engineering disciplinary practices, including proposing a model.

Ms Galván: Bien rápido energía radiante. Andrés, ¿qué es energía radiante?
Emmanuel: La luz del sol
Ms. G: La luz del sol, correcto. Jose, ¿qué quiere decir reflejar?
Jose: Que la luz rebota
Ms. G: Que la luz rebota o se regresa. Piensen. Cuando rebatan una pelota, ¿qué pasa todo el tiempo? Se les está regresando. Maribel, ¿qué es absorber?
Maribel: Es como si fuera una esponja que absorbe toda el agua
Ms. G: Ok, ese es un ejemplo. Muy bien, absorber, como tragar, como juntar ¿verdad? Ok, pregunta número uno. Para resolver su problema ustedes tienen que capturar la mayor ¿de qué, Zoey? ¿qué vas a capturar?
Zoey: El sol
Ms. G: El sol, la luz del sol, verdad? ¿Por qué, Catía? ¿Por qué hay que capturar la luz del sol? [Veronica levanta la mano]
Karol: Mm para que… [Veronica levanta la mano aun más] ¿haya calor?
Ms. G: Para que haya a calor o para que tu casa este calientita ¿verdad?
Veronica: O para que traigas energía pasiva, ¿verdad? [No la llamó Ms. G, pero levantó la mano y se empalmo su respuesta con la última parte de la respuesta de K]
Ms. G: (asintiendo) Para que tengas energía pasiva, muy bien. ¿Va a hacer una diferencia los materiales? Eso quiere decir ¿puedes usar cualquier material que yo quiera, que se venga a mi mente?
Estudiantes: No, no, no
Ms. G: Uuu [alzando la voz] ¿qué tipo de material, Valentina, sería el mejor?
V: El ladrillo
Ms. G: Ok, en este caso va a ser el ladrillo ¿por qué el ladrillo?
V: Porque el ladrillo es el que más absorbe la luz del sol
Ms. G: Exacto, pero en si sería cualquier material que pudiera absorber la luz del sol, el ladrillo no necesariamente. Y la última, el lado de la casa orientada al sur, ¿por qué tendría que estar nuestra casa hacia sur? Sergio ¿por qué crees tú que la casa debe estar mejor orientada hacia el sur?
Sergio: [No se distingue]
Ms. G: ¿pero qué piensas tú?Ve ahí tu dibujito. ¿Por qué debe ser al sur? ¿Por qué tu casa debe estar orientada hacia el sur? ¿Qué pasa en el sur? ¿Qué pasa en el sur, María? Ayuda a Sergio que es de tu grupo
Maria: El sol esta… ¿es invierno?
Ms. G: Ok, es el sol, acuérdate que el sol sale del lado sur cuando es invierno y vamos a atrapar toda la luz del sol

Ms. Galván: Really quick, radiant energy. A, what is radiant energy?
Emmanuel: The sun’s light
Ms. G: The sun’s light, right. Jose, what does “to reflect” mean?
Jose: That the light bounces back
Ms. G: The sun bounces back or returns. Think. When you bounce a ball, what happens all the time? It’s coming back. Maribel, what is to absorb?
Maribel: It’s as if it were a sponge that absorbs all the water
Ms. G: Ok, that is an example. Very good, to absorb, to swallow, to join, right? Ok, question number one. To solve your problem, you have to capture the most, what? Zoey, what do you have to capture?
Zoey: The sun
Ms. G: The sun, the sun’s light, right? Why, C, why do you have to capture the sun’s light? [Veronica raises her hand]
Karol: Mmm so that… [Veronica raises her hand even higher] there’s heat?
Ms. G: So that there’s heat or for the house to be warm, right?
Veronica: Or for you to bring in passive energy, right? [Ms. G did not call on her, but V raised her voice overlapping with the last part of K’s response]
Ms. G: [nodding] So you can have passive energy, very good. Will the materials make a difference? Does that mean that I can use whatever material I want or that occurs to me?
Se: No, no, no
Ms. G: Oooo [raising her voice] what type of material, V, would be the best one?
V: Brick
Ms. G: Okay, in this case it’s going to be brick, why brick?
V: Because brick is the one that absorbs the sun’s light the most
Ms. G: Exactly, but actually it can be any material that could absorb sunlight, not necessarily brick. And lastly, the house’s orientation toward the south, why should it face south? Sergio, why do you think the house should be oriented toward the south?
Sergio: [Indistinct]
Maria: The sun is… Is it winter?
Ms. G: Okay, it’s the sun, remember the sun comes out from the south in the winter and we are going to capture all the sunlight
In the above video transcription excerpt, we showcase the cases of two students, Veronica and Sergio. Veronica was a “Spanish-dominant,” transfronteriza student who had recently started school in the USA and Sergio was an “English dominant” Latino. To begin, the example illustrates Veronica’s eagerness to participate while the teacher calls on other students. When the teacher asked Karol to respond, she raised her hand, and when Karol responded to the question with some doubts and without many details, Veronica raised her hand even higher. When the teacher did not acknowledge her, Veronica raised her voice and gave her response without waiting to be acknowledged. “O para que traigas energía pasiva, verdad?,,” overlapping with the last few words uttered by Karol. The example also illustrates Veronica’s use of a concept that the teacher had just explained a few moments prior, during her lecture with the whole class: “energía pasiva.” We see how the students engage in “meaningful participation in practices in which children can extend and appropriate tools to use in the service of meaning-making” (Gutiérrez et al., 2011, p. 236). In particular, the case of Veronica, a Spanish-dominant student, suggests that the dual language learning ecology allows for her participation in the language of the day, which happened to be her dominant language. In an English-only learning ecology, it is likely that she might not participate in the agentive and meaningful way she did in her dominant language. The excerpt shows how she used the knowledge gained from the disciplinary practice of testing materials and the concept of energía pasiva. The excerpt also suggests that Veronica’s social interaction with people and texts in the learning ecology of the dual language space also mediated her participation. Namely, she took up bits of language from her teacher’s lecture, from the text she read, as well as the worksheets that she completed with her peers. Taken together, social interactions while participating in engineering disciplinary practices (e.g., building a model) and while interacting socially with others constituted a learning ecology that would allow her and the other students to continue engaging in engineering disciplinary practices. As students continued to engage in the engineering design cycle, these tools and interactions afforded this learning ecology for meaning-making.

The above excerpt also allows us to illustrate the case of Sergio. Because the excerpt is taken from a “Spanish day” he might not have produced a discernible verbal response to the teacher’s question in the language of the day (“¿por qué crees tú que la casa debe estar mejor orientada hacia el sur?”). In fairness, he might not have answered discernibly because he did not know the answer to a challenging question. Seeing his lack of an expected response, the teacher positioned herself physically next to him in a nonthreatening way and gently pointed at the workbook. Next, she recommended that he use multimodal resources, i.e., his drawing of the house model oriented in relation to the sun which students had completed previously. “Ve tu dibujito,” she said sweetly. From the excerpt we may infer that, in the learning ecology of dual language, multimodal tools mediate understanding as much as oral language does. Images that were available in the workbooks and the textbook were tools that students used as part of the assemblage (Pennycook, 2017) to make meaning. The excerpt shows how the teacher recognized the importance of multimodality to mediate understanding for an EB, in this case an English-dominant student (Sergio). The example illustrates the hybridity of interactions in a multilingual learning ecology, where students drew on oral and literate practices, bits of language in different voices, and in different languages and different modalities (drawings and gestures). As Gutiérrez et al. (2011) write, in this example we notice “the production of hybrid texts that necessarily draw on everyday and school based knowledge and conventions” (p. 236).

In addition, this episode also reminds us of the transformative power of translanguaging, where it can be part of an effort to humanize education with cariño (care) (Sánchez & García, 2022). Sergio’s indistinct answer prompted the teacher to allude to the value of compañerismo (collegiality) in the DLBE space. Ms. Galván asked Maria to support him by simply saying “Sergio es de tu grupo,” meaning that what affects Sebastian also affects Maria. This interaction suggests that, beyond teamwork in engineering learning where equipos de ingenieres work together under set constraints to meet the

Table 2  
Summary table for the 12-day unit.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Language of the day</th>
<th>Engineering practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/16/2018</td>
<td>Spanish</td>
<td>Setting up the problem</td>
</tr>
<tr>
<td>2</td>
<td>1/17/2018</td>
<td>English</td>
<td>Testing building materials</td>
</tr>
<tr>
<td>3</td>
<td>1/18/2018</td>
<td>Spanish</td>
<td>Defining the problem</td>
</tr>
<tr>
<td>4</td>
<td>1/19/2018</td>
<td>Spanish</td>
<td>Starting to work on a budget</td>
</tr>
<tr>
<td>5</td>
<td>1/20/2018</td>
<td>English</td>
<td>Finalizing budget, calculating costs</td>
</tr>
<tr>
<td>6</td>
<td>1/21/2018</td>
<td>Spanish</td>
<td>Starting to build a model</td>
</tr>
<tr>
<td>7</td>
<td>1/22/2018</td>
<td>English</td>
<td>Mid-point science presentations</td>
</tr>
<tr>
<td>8</td>
<td>1/23/2018</td>
<td>Spanish</td>
<td>Start to test the model</td>
</tr>
<tr>
<td>9</td>
<td>1/24/2018</td>
<td>Spanish</td>
<td>Finish testing the model</td>
</tr>
<tr>
<td>10</td>
<td>1/25/2018</td>
<td>Spanish</td>
<td>Determine of model was successful</td>
</tr>
<tr>
<td>11</td>
<td>1/26/2018</td>
<td>Spanish</td>
<td>Reflect and justify the model</td>
</tr>
<tr>
<td>12</td>
<td>1/27/2018</td>
<td>English</td>
<td>Presenting findings</td>
</tr>
</tbody>
</table>
needs of their “cliente,” the DLBE community can be a humanizing space. Learners are more than their label (e.g., Spanish-dominant or ELL), and assistance goes beyond simply translating: it includes making others feel part of the group.

In addition, another example of expanding a repertoire of practices (which we call “stretching”), to add engineering disciplinary practices, comes on day ten of the unit. After students had finished building and testing their model, on a “Spanish day,” teams were determining if their models had been successful based on the given design criteria. Ms. Galván met with one of the teams after they had been discussing the topic for a few minutes. This team had chosen to use a model with light tile flooring instead of the brick flooring, which they knew was the flooring the tests showed was the best material to heat the solar house. The team’s model had met the criteria for success despite going with the unconventional choice. However, Ms. G wanted them to justify the reasons why their design was successful, as shown below. These two engineering disciplinary practices are important because, if they were to redesign, they would implement these changes.

Ms. G: ¿Quién me puede explicar? Uno de ustedes diganme por qué su modelo fue exitoso. A ver, Gastón, ¿por qué?

Gastón: Porque estuvo… después que se acabaron los 20 minutos con la lámpara prendida [la temperatura] estuvo .4 grados Celsius más arriba de lo esperado y cuando la lámpara estaba apagada subió 0.8 grados

Ms. G: ¿0.8 o 1.8?

G: 0.8 más de [la temperatura] esperada

Ms. G: 1.8 porque si fuera 0.8 no cumpliría [el criterio]

G. Más de [la temperatura] esperada

Ms G: Aja. Okey, ahora, si pudieran cambiar algo ¿qué le cambiarían?

G: Ma´s de lo esperado y cuando la lámpara estaba apagada subió 0.8 grados

Ms: G: [translating for Corina] Did the floor affect the temperature? Corina: I would think the floor was okay

G: Sí, dice que sí

Ms. G: ¿Entonces qué? El piso estaba bien

G: Sí

Ms. G: Porque veo que la temperatura subió muchísimo más de los cuatro [grados] sin embargo aquí estuvieron muy cerca de no haberla cumplido [los criterios]. ¿Qué creen que afectó? Ella dice que fue donde posicionaron las ventanas [hace gesto] de los lados. ¿Tú estás de acuerdo?

G: Aja

Ms. G.: ¿Quién más piensa que fue otra cosa?

G Pues si hubiéramos podido poner [la casa hacia] el suroeste o el sureste hubiera estado mejor porque [el sol] le hubiera dado en frente de la casa y a un lado de la casa


Ms. G: Who can explain to me? One of you tell me why your, ah, model was successful. Let’s see, Gastón, why?

Gastón: Because it was… After 20 minutes with the lamp on, [the temperature] was .4 degrees Celsius higher than expected and when the lamp was turned off, it rose 0.8 degrees

Ms. G: 0.8 or 1.8?

G: 0.8 above the expected [temperature]

Ms. G: [You mean] 1.8 because if it were 0.8 it would not meet [the criterion]

G: More than the expected [temperature]

Ms. G: Aha. OK, now, if you could change something, what would it be?

[...] Do you think the flooring affected [the results]? Are you okay with the floor? Someone else…

G: [translating for Corina] Did the floor affect the temperature?

Corina: I would think the floor was okay

G: Yes, she says yes

Ms. G: So then, what? The floor was fine

G: Yes

Ms. G: Because I see that the temperature rose much more than the four [degrees], however here they were very close to not having met [the criteria]. What do you think affected it? She says that was where they positioned the windows (gestures) on the sides. Do you agree?

G: Aha

Ms. G: Who thinks it was something else?

G: Well, if we could have put [the house facing] the southwest or southeast it would have been better because [the sun] would have hit in front of the house and on one side of the house

Ms. G: And on one side of the house. Very true. Yes it is true because the way we have the [model], the sun right now is simply facing south [Gastón: South]. The south. Yes, that’s right.

The above video transcription excerpt shows how the teacher, through her questioning, scaffolds students’ elaborated responses as they seek to address Ms. G’s questioning. To summarize, Ms. G gently challenged the team because it chose an unexpected material (light tile versus brick). In response, the team, represented by Gastón, doubled down and explained why the model design was successful and he justified which design choices they would make upon redesign. In response to Ms. G’s insistence that the model was almost unsuccessful, Gastón added that, in addition to the factor of flooring and the number of windows, another key factor that would have improved the model would be to position it facing south in relation to incoming sunlight. In addition, as part of a multilingual learning ecology, Gastón translated for a Spanish-dominant peer (Corina) and he translated Corina’s response to the teacher. The excerpt suggests that expansion or stretching occurs in collaboration between Gastón and Ms. G.

The above example suggests that a multilingual learning ecology afforded students ample opportunities to engage in engineering disciplinary practices. Students’ meaningful participation created a learning ecology “in which children can extend and appropriate tools to use in the service of meaning-making” (Gutiérrez et al., 2011, p. 236). It also shows students participating agentively to create that ecology, such as when Gastón included Corina in the conversation through translation, or when Martha used the map and the drawings to support her explanation.
Discussion

Students labeled as ELLs are sometimes excluded from participating in agentive learning experiences (Adair et al., 2017) owing to the misconception that they lack the prerequisites to engage in such experiences (National Academies of Sciences, Engineering, and Medicine, 2018). In this article, we focused on a learning ecology that was composed by a majority of Latinx students and their two Latina bilingual teachers. Efforts to broaden participation in engineering among marginalized groups frequently focus on bolstering science and mathematics achievement, which Calabrese Barton et al. (2021) argue elides social and cultural aspects. They write that “the social aspects of engineering by and with people may contribute to student learning and engagement in pre-college engineering” (p. 91, emphasis is ours). Heeding this urgent call, we contribute to the literature on engineering education in elementary classrooms by highlighting social and cultural aspects of a multilingual learning ecology in a DLBE context.

In the multilingual ecology we studied, participants, including EBs (some labeled as “LEP”), actively engaged in agentive engineering design activities. They engaged in engineering disciplinary (bi)literacy practices: reading, writing, and interpreting multiple forms of engineering-related texts. Together, the class went through the engineering design cycle using disciplinary tools. They identified a problem, tested materials, proposed a model, tested the model, determined if it was successful, identified what they would change to improve the model, and communicated their findings. Through every part of the cycle, they drew on the resources available in the bi-/multilingual learning ecology. Furthermore, multilingual learning ecologies, such as the DLBE classroom we studied, create affordances for engineering learning. Specifically, these ecologies can afford students opportunities to use engineering disciplinary biliteracy practices.

In a multilingual learning ecology both teachers and students normalized translanguaging practices. Translanguaging was truly the everyday language practice in la frontera. Although monoglossic ideologies circulated in schools—enacted by mezzo-level policies of language separation (“Spanish Day” and “English Day”)—and macro-level deficit policies (“LEP”), participants in the classroom ecology enacted everyday translanguaging practices and created a hybrid fronterize (borderland) space.

Implications for research and policy of this research is that multilingual learning ecologies, such as the DLBE classroom we studied, can afford the use of multiple forms of communication, including two named languages, English and Spanish, translanguaging practices, visual, gestural, and artifactual communication. Policies that allow for the creation of multilingual learning ecologies, such as in DLBE programs, afford the possibility for students to add multimodal, engineering disciplinary biliteracy practices to their repertoire.

Translanguaging as a tool for learning was used freely and flexibly as a meaning-making tool, as a tool to distribute engineering knowledge during whole-group and small-group discussions, and as a tool to connect with engineering concepts previously learned in another language. Translanguaging was used agentively for the shared purpose of engaging in the engineering project design. The instances mentioned here are representative of the recurrent use of translanguaging, including translations. This was seen when the language of the day was one with which their peers needed help. Mixing English and Spanish when explaining their reasoning behind a design decision was also recurrent. Translanguaging was also evident during whole-group discussions, when the teacher generally used the language of the day, but students flexibly used their entire repertoire of languaging practices.

An important aspect of engineering learning in this DLBE program is that learning was organized around activities that afforded engagement and enthusiasm among students, who imagined that they were engineers building a solar house or building an earthquake-safe tower. We contend that the use of two languages and translanguaging afforded the agentive participation of all students. We observed meaningful learning when students were invested in understanding through translanguaging the criteria necessary to design their houses. The DLBE engineering ecology afforded students the roles of experts in multiple ways, in particular, because they were able to use their whole linguistic repertoires, as the case of Veronica suggests. This ecology afforded multiple forms of assistance and participation through translanguaging in the moment of interaction, as well as across time, as shown in the above section. In sum, this learning ecology afforded opportunities for students to add to their repertoires of biliteracy disciplinary practices. We observed students, across the 12-day engineering project, learning new engineering discourse and adding it to their toolkit that they were to use later to learn and make meaning. These are expansive forms of learning (Engeström, 1987) engineering through translanguaging.

Our findings suggest that translanguaging that flows throughout the learning ecology afforded participation and created a space for equitable participation for Latinx students, including many labeled as ELLs. As we considered collective activity, we must note that participation might have been different for each individual student according to the particularities of their own linguistic repertoires. Depending on the language of the day, some students had access to more features of both named languages than others. However, if we analyze the processes and practices of the learning ecology, and not an individual student’s languaging, we see what the collective accomplished, en conjunto. In other words, distributed linguistic expertise
was at play. Furthermore, as the unit unfolded, it became evident that students’ engineering knowledge and (bi)literacy practices expanded to support students’ agentic identities.

An implication for bilingual education is that hybrid, multilingual learning ecologies present a clear alternative to the restrictive monolingual and monoglossic classroom ecologies in majority-language-oriented bilingual education classrooms. Additionally, bilingual teacher educators and engineering educators must consider ways to engage bilingual Latiné learners, including EBs. We believe that it is critically important to relate social justice and S&E education for these populations. Such an effort engages communities to examine issues from “historicized lenses, and understands how contemporary scientific practices or concepts may have deep roots in racist or other oppressive histories” (National Academies of Sciences, Engineering, and Medicine, 2022, p. 27). Similarly, Rodriguez (2015) calls for centering equity and social justice in recognizing teachers who work with students labeled as ELLs. Rather than considering equity as an “add on,” he argues that these issues are “essential to truly enact the standards for all students” (p. 1044). For example, the bilingual teachers here did not have an identity as scientists or engineers. Both teachers were formerly labeled as ELLs and were likely impacted by exclusionary policies that steered them away from the S&E learning experiences they were leading. Although they had a robust commitment to serve EB students equitably, they did not see this commitment as central to S&E learning. They worked with commercially available, pre-existing engineering modules, instead of starting with students’ own observations and wonderings. Future efforts in working with students labeled as ELLs and Latiné populations must center equity and social justice and build on learners’ funds of knowledge (Mejia et al., 2018).

Limitations

This article presents an in-depth investigation set in a specific time, geopolitical space, and curricular context (i.e., DLBE in a STEM-focused school on the USA–Mexico border). The findings presented may provide valuable insights that can transfer to other settings with similar policy contexts (e.g., DLBE). However, they are not meant to be generalizable to other settings or populations with students categorized as ELLs. We recognize that we describe here a particular situation at the USA–Mexico border, which includes DLBE programs with bilingual teachers and bilingual families and communities that translanguage for content learning. Not all DLBE setting programs and teachers have the same bilingual phenomena. Although these characteristics may present a limitation for generalizability and replicability, as qualitative researchers, these are not our research goals.

Conclusion

In this article we used a learning ecology theoretical framework to analyze data gathered from an ethnographic study of fourth-grade DLBE classes. We argue that the DLBE framework afforded the creation of a multilingual learning ecology. We showed how DLBE language policies allowed for an ecology where practices included the use of multiple language practices and modalities to mediate engineering design activities. We also showed how students agentively stretched their repertoire to add engineering biliteracy disciplinary practices (e.g., discussing design problems, building and testing a model, and communicating their findings).

Author Bios

Alberto Esquinca is an associate professor in the Department of Dual Language & English Learner Education at San Diego State University. He prepares bilingual teachers and researches language and literacy practices in the context of science and engineering. Email: aesquinca@sdsu.edu

María Teresa de la Piedra is a professor of bilingual education in the Department of Teacher Education at the University of Texas at El Paso. She is an educational anthropologist who conducts research in U.S. and Peruvian bilingual education contexts. Email: mdelapiedra@utep.edu

Lidia Herrera-Rocha is an assistant professor of instruction in the Department of Teacher Education at the University of Texas at El Paso. She prepares bilingual teacher candidates during their teaching residency and engages in research focused on ideologies, identities, and bilingualism. Email: lherrera2@utep.edu

References


https://doi.org/10.7771/2157-9288.1369