Translanguaging in Computer Programming: "¿Qué no es un cereal?"

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ABSTRACT: Although there have been efforts to broaden the participation of underrepresented students in Science, Technology, Engineering, and Mathematics (STEM), few studies have focused on how Latine bilingual students in rural contexts can access computer programming. The purpose of this case study is to examine how translanguaging facilitates understanding among emergent bilingual students. The findings showed how translanguaging is more than translation, how students used their linguistic repertoire to negotiate meaning, and the use of language brokering as a pedagogical tool. Implications for translanguaging in STEM have the potential for a deep understanding of computer programming concepts.

KEYWORDS: Translanguaging, STEM education, middle school, computing, bilingualism

Although there have been efforts to broaden the participation of underrepresented groups in science, technology, engineering, and mathematics (STEM) (Francis & Askew, 2022), there is a lack of studies that investigate how emergent bilingual students use translanguaging to engage and make meaning of computer programming (Celedón-Pattichis et al., 2024; LópezLeiva et al., 2021; Vogel et al., 2020). In 2025, it is estimated that one fourth of children in classrooms nationwide are bilingual/multilingual (National Education Association, 2020). However, emergent bilingual students learning English in rural contexts are less likely to be taught computer science (Code.org Advocacy Coalition, 2018). While there is a tremendous increase in emergent bilingual students in U.S. classrooms, three-fourths speak Spanish as their first language (Thompson, 2021). The Latine[1] population reached 62.5 million in 2021, making it 19% of the U.S. population (Zong, 2022). The projected growth for the Latine population is 111.2 million, or 28% of the U.S. population, by 2060.

Given that the number of emergent bilingual students who are Spanish speakers is increasing steadily, there is a solid need to afford these students opportunities to learn computer programming in multilingual settings. However, only 35% of high schools in the U.S. teach computer science (Code.org Advocacy Coalition, 2018). Research shows that emergent bilingual[2] students' language development is best supported when they are allowed to actively engage with new content using their full linguistic repertoire (Lee et al., 2023). However, linguistically diverse students are asked to perform as if they were monolingual (García & Yip, 2015). A translanguaging framework proposes looking at "bilingual children's linguistic performances from their *internal perspective*, from the child's use of language" (García & Yip, 2015, p. 2). From this perspective, a translanguaging lens allows us to link emergent bilingual students' full use of their Spanish when learning STEM concepts. We aim to demonstrate how emergent bilingual students operate with a unified linguistic system, rather than treating their languages as separate entities (García, 2009a).

While there have been studies conducted to examine the use of translanguaging in mathematics education (Garza Ayala, 2020; Maldonado Rodríguez et al., 2020), in science education (Andersen et al., 2022), and in computer programming (Celedón-Pattichis et al., 2022; Radke et al., 2022), there are fewer studies that have considered the integration of mathematics and computer programming in multilingual settings. This study advances knowledge in understanding how we can broaden the participation of rural middle school emergent bilingual students in STEM through the use of translanguaging using Python, a text-based computer programming language. This study differs from others in that most studies have focused on using Scratch. The primary difference between Scratch and Python is that Scratch is a visual, block-based environment designed for beginners, where blocks are dragged and dropped to develop programs, while Python is a text-based programming language written in English with a steeper learning curve, used for more complex applications like Artificial Intelligence (AI), web development and data analysis, requiring users to write code.

[1]Latine is a gender-neutral term created as an alternative to terms like Latino, Latina, and Latinx.

[2]An emergent bilingual is a student who is actively learning and developing proficiency in a second language while also maintaining their primary home language.

Our research aspires to show the affordances given to emergent bilingual students in an after-school coding program where students process knowledge with no constraints on using their home language to assist in writing and comprehending code. As bilingual researchers, we wanted to examine how translanguaging (García, 2009a) facilitates learning. Thus, we pose the following research question: How do translanguaging practices facilitate interactions and promote learning among emergent bilingual students in an after-school coding program?

Theoretical Perspectives

The term translanguaging was created by the Welsh educationalist Cen Williams (Baker, 2003, 2011) in the 1980s to describe the systematic use of two or more languages for learning. Translanguaging is "a process whereby one language reinforces the other to increase understanding" (Williams, 2002, p. 40). García (2009a) treats translanguaging as a strategy that emergent bilingual students use to make meaning, shape their experiences, gain understanding, and make sense of their multilingual worlds through the everyday use of two or more languages. García (2009b) suggests it is impossible to live in multicultural communities and communicate among multilinguals without translanguaging.

Within the same thought process, emergent bilingual students, when learning new concepts such as STEM concepts, do not switch off their cultural identity or home language (Fishman, 1977; Howard et al., 2007; Lucido et al., 2024). Justice-centered STEM education is inclusive of the students' wealth of culture and language, which are assets in learning (Lee & Grapin, 2022). Using translanguaging methods specifically highlights students' linguistic repertoire in STEM. Through translanguaging methods, we look at learning in bilingual settings as a sociolinguistic approach beyond two separate languages (Cummins, 2007) and draw on emergent bilingual students' rich and varied resources. During knowledge construction, emphasis should also be given to the processes of "mixing of cultures and world views" (Brutt-Griffler & Varghese, 2004, p. 94), creating equitable learning spaces where students can learn and "recontextualize identities into new contexts" (García, 2017, p. 23). Translanguaging can be a linguistic tool to overcome invisible multilingualism, such as when someone is proficient in two or more languages, but their bilingualism is not acknowledged by society (Gkaintartzi & Tsokalidou, 2011). Invisible multilingualism needs to be overcome to foster opportunities and diversify the STEM field.

We aspire to use translanguaging as a lens to understand a flexible bilingual approach, inclusive of bilingual literacy practices in computer programming and mathematics. Jacob and Warschauer (2018) define literacy as "a set of practices situated in a sociocultural context that utilizes external technological media to enable expression" (p. 285). Vogel et al. (2020) recommend translanguaging as a method for including emergent bilingual students in computing discourse by leveraging their entire linguistic repertoire for sense-making instead of assuming emergent bilinguals cannot engage in the STEM field. Literacy in computer programming showcases the ability to read, write, comprehend, and modify to problem solve. Learning to code in multilingual settings involves the purposeful use of multiple languages simultaneously to inquire, dissect, analyze, and brainstorm solutions. However, English continues to be the privileged language for STEM (Mejia et al., 2020). We aim to use translanguaging as a lens to counter the prescriptive nature of English-only ideologies in the U.S. educational system.

Review of the Literature

Translanguaging has the potential to leverage a student's dynamic bilingualism by providing spaces where students utilize their linguistic tools to communicate across numerous contexts (Ebe & Chapman-Santiago, 2016; García, 2009b). It allows multilingual speakers to flow between languages, "treating the diverse languages that form their repertoire as an integrated system" (Canagarajah, 2011, p. 401). For this reason, we seek to analyze patterns in how emergent bilingual students in a coding program dialogue new concepts using their linguistic varieties (Rymes, 2015). The following literature review focused on translanguaging in classroom settings and mathematics/computer science settings.

Translanguaging in Classroom Settings

Translanguaging can function as a classroom-planned practice where teachers implement strategies and lessons in response to students' language practices and prior knowledge, also called "pedagogical translanguaging" (Cenoz, 2017, p. 194). Pedagogical translanguaging allows students in classroom settings to think and problem-solve using multiple languages simultaneously. However, the dominant ideology of many schools with bilingual programs is to separate instruction, where part of the day's learning occurs in English and part occurs in the student's home language, often discouraging translanguaging (Ascenzi-Moreno & Seltzer, 2021). Pedagogical translanguaging opposes the ideology of asking emergent bilingual students to use only English to make meaning of new concepts. Instead, pedagogical translanguaging encourages students to leverage both the home language and English for input and output.

Pedagogical translanguaging liberates speakers from strict linguistic ideologies while embracing real-life communication practices (Cenoz & Gorter, 2020). Translanguaging in classrooms provides an opportunity for collaborative learning where emergent bilingual students engage in activities, using multilingual discourse (Martin-Beltrán, 2014) and building knowledge (Woodley & Brown, 2016). In a study conducted by Collins and Cioé-Peña (2016), students reported increased self-confidence and understanding of content when allowed to use both Spanish and English simultaneously (Otheguy et al., 2015; Wei, 2018). Flores and García (2013) noticed students' heightened interest when they were encouraged to use translanguaging in discussions. Velasco's and Garcia's (2014) study highlighted that, when translanguaging was the norm, "...emergent bilinguals can, and do, self-regulate and advance their learning" (p. 21), sustaining their multilingual language practices and cultural identity.

Traditionally, content learning emphasized the acquisition of information or rote learning practices where repetition techniques were part of acquiring new knowledge, giving recall priority rather than deep understanding (Mayer, 2002; Stefansson et al., 2021; Tokuhama-Espinosa, 2010). Such practices have been criticized for leaving “no room for exploration and critical thinking” (Pande & Relia, 2020, p. 40). However, math and science classrooms today encourage inquiry, meaningful learning, and precise discourse (National Council of Teachers of Mathematics [NCTM], 2014; National Research Council, 2013). Drawing from translanguaging and inviting emergent bilingual students into new ways of inquiry and meaning making can serve as a bridge to reaching these goals in mathematics and computer science.

Translanguaging in Mathematics and Computer Science

Within the same thought process, emergent bilingual students do not switch off their cultural identity or home language when learning STEM concepts. Garza Ayala’s (2020) ethnographic case study conducted in a dual language classroom revealed how successfully the students and their teachers utilized students’ home language along with English while learning mathematics concepts despite language separation policies. Similarly, Ji-Yeong and Martinez (2020) and Hansen-Thomas and Bright (2019) found that the fluidity of language contributed to an inclusive learning environment where students' comprehension of mathematical concepts increased when they used both their home language and English. Furthermore, a mixed-methods study involving Spanish-speaking high school English learners emphasized the benefits of utilizing students' full linguistic repertoire, inclusive of their home language, during mathematics assessments (Lopez, 2023). In all mentioned studies, students were able to demonstrate their mathematical abilities better when allowed to learn in their preferred language(s).

The work of translanguaging also extends into computer programming. In a study by Vogel et al. (2020) between university researchers and the New York City Department of Education, three middle schools with bilingual programs explored the implementation of translanguaging to bolster students' grasp of computer science. The inquiry discovered that enabling students to harness their complete linguistic, social, and semiotic resources facilitated vocabulary expansion and fostered the comprehension of computer programming. For instance, students became empowered to juxtapose *telenovelas* (Spanish soap operas) with the computer program Scratch, which enabled them to fabricate scenarios. This pedagogical approach involved the dynamic employment of student culture along with the use of both Spanish and English, effectively propelling the acquisition of new vocabulary linked to computer programming (Vogel et al., 2020). Asset-based translanguaging approaches that honor students' multifaceted identities and linguistic proficiencies enhance knowledge and understanding in STEM education for emergent bilingual students (Celedón-Pattichis et al., 2022). As students grow in linguistic sophistication across multiple languages, their process parallels computational literacy development: coding and decoding, becoming more fluent, and using coding to meet their own needs and express their ideas (Bers, 2019).

Collectively, these studies highlight that emergent bilingual students thrive in learning environments that use translanguaging, inclusive of students’ home cultures, to make meaning of complex concepts in mathematics and computer programming. We note that in most of these studies, the student populations were English-Spanish speakers where these languages were also common to the teachers. As Pierson and Grapin (2021) indicated, there may be challenges in implementing translanguaging when there are students from multiple linguistic backgrounds and a monolingual teacher who may not be prepared to handle the complexities of using multiple languages in the classroom. However, while there are challenges in implementing translanguaging, there is also evidence from these studies that translanguaging can support deeper learning when done purposefully. Most importantly, these researchers of translanguaging in STEM challenge monoglossic language ideologies and counter monolingualism as the norm. Bilingual students are expected to fit within a society that values English in academics and appreciates Spanish as a foreign language (García & Torres-Guevara, 2009). However, using translanguaging in STEM learning values emergent bilingual students' use of both their English and Spanish.

Context of the Study: AOLME Project

The Advancing Out-of-School Learning in Mathematics and Engineering (AOLME) project's central goals were to develop, implement, and revise an integrated mathematics and computer programming curriculum. An interdisciplinary team of researchers from electrical and computer engineering and bilingual/mathematics education joined to co-develop the AOLME curriculum and implement it through an after-school program (Celedón-Pattichis et al., 2013). The implementation was held in bilingual middle schools with the support of facilitators, typically undergraduate or graduate engineering students; a co-facilitator who was a middle school student having experienced Level 1 of the curriculum (described in the next section); two bilingual teachers from the school; and the AOLME team, which included the researchers.

The AOLME curriculum included two levels. Each level of the curriculum was developed in both Spanish and English so that facilitators had the option of teaching it in either language, depending on the middle school students' language preferences. It is important to note that, although the curriculum tasks were developed in Spanish and English, the programming language used, Python, was in English only. Thus, the facilitators, co-facilitators, and middle school students determined how students used their integrated linguistic repertoire to negotiate meaning of the mathematics and computer programming concepts. Level 1 of the curriculum focused on basic concepts of computer programming, such as variables, strings, For Loops, and binary and hexadecimal numbers, among other concepts, to understand how to process black and white and color images and video. Level 2 of the curriculum focused on object-oriented programming and robotics. For more details of the Level 1 curriculum in English and Spanish, please see https://aolme.unm.edu/WebsiteModel/template/level_1.html.

This study focused only on Level 1 curricula, concentrating on the basics of computer programming using image and video processing. The Level 1 curriculum was implemented over 12 sessions in the after-school program, each lasting one and a half hours. Seven of the sessions focused on content learning and five on applying what students learned from the Level 1 curriculum to create a video based on their interests. Middle school students' families, friends, teachers, and the principal were invited to a graduation ceremony where the students presented their final projects and the AOLME research team discussed the college-going process and pathways to continue into STEM fields. We chose to use the computer programming language Python because of its usability for introductory programming courses and its usage as the standard language for developing AI systems.

To prepare the middle school teachers and undergraduate and middle school co-facilitators to implement the curriculum in the after-school program, we held four six-hour professional development sessions during the spring semester to implement Level 1 of the curriculum, and we held the same number of sessions for implementation of Level 2 of the curriculum during the summer. These professional development sessions focused on viewing the students' languages and cultures as a resource (Ruiz, 1984), including translanguaging practices that supported students' meaning-making of mathematics and computer programming concepts. Professional development sessions included topics such as cooperative learning, mathematics talk moves (e.g., revoicing, reasoning, adding on to peers' responses, turning and talking with a partner, among others) (Chapin et al., 2022), asset-based approaches in teaching and learning mathematics and computer programming (Celedón-Pattichis et al., 2018; Celedón-Pattichis et al., 2022), and the AOLME curriculum tasks so that facilitators would become familiar with the same activities the middle school students would undertake. As a research team, we engaged with situated professional development (Cobb et al., 2003), which meant that we adapted to the students' and teachers' lived realities in the school settings and schedules.

Method

This case study explores the participation of Latine emergent bilingual students in an after-school program dedicated to enhancing participation of underrepresented students in STEM. We begin by discussing the research design, site and participants, and our researcher positionality. Then, we describe the data collection, ethical considerations, and the process we used for data analysis.

Research Design

A case study approach grants a thorough understanding of emergent bilingual students in an after-school program. An empirical case study must be bound and "...investigat[e] a contemporary phenomenon within its real-life context" (Yin, 2003, p. 13). Our approach of an intrinsic interpretivist single case study allowed an in-depth understanding of an outlier case (Thomas, 2021), which, in our project, consisted of Latine middle school students enrolled in an after-school STEM program in a rural context. These students of color faced systematic barriers in accessing quality STEM education and pursuing STEM careers despite showing interest in mathematics and science. For this reason, an interpretivist approach gives an understanding of how the participants as emergent bilingual students used their linguistic repertoire to make sense of STEM concepts.

Site and Participants

AOLME was implemented as an after-school program in two bilingual middle schools in the Southwest region of the United States. One school was in a rural context, and the second school was in an urban context. Both schools served primarily Latine students, who comprised over 92% of the student population, and all students were on free or reduced lunch. This study specifically focuses on the rural middle school where students were taught mathematics in Spanish in the sixth and eighth grades and English in the seventh grade.

AOLME enrolled 135 middle school students, consisting of three cohorts, of which 24 total students served as co-facilitators. Students who became co-facilitators had experienced Level 1 of the curriculum during the previous year's after-school program. The co-facilitators were mentored by a facilitator who was either an undergraduate or graduate student at a nearby university. For the purposes of this paper, we focus on one of the ten groups from Cohort 3 (Spring 2019), made of 4 students with one facilitator (graduate student) and one co-facilitator (former middle school participant in the program). The group consisted of Fu, the facilitator, whose home language is Vietnamese, is fluent in English, and has beginning knowledge of Spanish; Juanita, the co-facilitator, a 6th grader whose home language is Spanish and indicated her hobby was dancing and her favorite subject was mathematics; and four middle school students. Vicente was a sixth grader whose favorite hobby was playing soccer. Tina was a 6th grader who enjoyed playing basketball, and her favorite subject was physical education. Josephina was a 6th grader who identified playing as her favorite thing to do. Ariel was a 7th grader who enjoyed music and described science as his favorite subject. Apart from Juanita, the middle schoolers were all newcomers from México to the U.S. and considered English learners in their school. The facilitator and co-facilitator acted as computer programming tutors and language mediators, allowing translanguaging to emerge naturally. All students self-rated themselves related to their use of languages in different domains (i.e., reading, writing, listening, and speaking) (see Table 1).

Table 1
Participants

Name	Role	Language 1	Language 2	Linguistic Repertoire
Fu	Facilitator	Vietnamese	English	Fu is multilingual with a repertoire that includes both Vietnamese and English. Self-reports as Beginning Spanish.
Juanita	Co-facilitator	English	Spanish	Self-reports as more comfortable in English. She is Advanced Spanish/Advanced English.
Vicente	Student	Spanish	English	Self-reports as Advanced Spanish/Beginning English.
Tina	Student	Spanish	English	Self-reports as Advanced Spanish/Beginning English.
Josephina	Student	Spanish	English	Self-reports as Advanced Spanish/Beginning English.
Ariel	Student	Spanish	English	Self-reports as Advanced Spanish/Intermediate English.

We selected this particular group because of the unique cultural and language dynamics that existed among the group and their use of translanguaging to understand and communicate mathematical and computational thinking related to Loops, a foundational topic in computer programming. Repetitive tasks are common in programming, and Loops are essential to save time and minimize errors. We used Python Loops to iterate a sequence of numbers.

Researcher Positionality

The research team shares a deep commitment to exploring how mathematics and computer programming can be integrated in ways that are linguistically accessible for bilingual students. Our research is driven by a belief that all students can engage in challenging tasks when they are afforded opportunities to do so using a text-based programming language, Python. Four of the researchers are of Mexican descent and one is Cypriot Greek, with extensive experience in Latine communities to advance their understanding of STEM. As transnational scholars, the research team's ideology views emergent bilingual students' languages and cultural backgrounds as resources (Ruiz, 1984). Translanguaging provides a learning space without borders, straddling multiple worlds living in *nepantla*, the in-between lands (Anzaldúa, 1987). For us, translanguaging goes beyond being able to speak more than one language. Instead, it is border thinking (Mignolo, 2000), where learning is inclusive of our multicultural and multilingual experiences tied to historical and sociocultural relations. Given our diverse backgrounds and experiences, we are committed to creating equitable educational opportunities for all students.

As a research team, we acknowledge that our positionalities inevitably shape the research we conduct, including the questions we ask and the ways we interpret data. We recognize that our identities may influence the relationships we form with our participants. Our identities can create power dynamics and biases in interactions with the participants. By reflecting on these positionalities, our goal is to engage in research that is both ethically responsible and culturally sensitive, ensuring that the outcomes of our work contribute to the advancement of educational practices that support bilingual students in learning mathematics and computer programming.

Data Collection

Over 1,200 hours of video data were collected over three years for the AOLME program. This number represented the data collected from five small groups at each school over the Spring and Summer of each year. For this study, we focused on two one-hour and forty-minute sessions held in March 2019. The data sources collected included video recordings, artifacts, and student exit interviews.

Video data were used to record interactions between the participants to analyze their dialogue and language choice when trying to understand new STEM concepts. While students participated in problem-solving, screen recordings were used to capture the students' coding activity. This process assisted the research team in noticing how students were interchangeably making meaning of programming language concepts while dialoguing with the facilitator and co-facilitator in both Spanish and English.

Students captured their learning in reflective journals. The students documented their learning throughout the after-school program and jotted down their feelings around the new knowledge acquired. We also drew from students' exit interviews that ranged from twenty to thirty minutes each. During the exit interviews, students chose to answer in English or Spanish. The students were provided with a 1-to-10 scale to reflect on their learning experiences before and at the end of the after-school program. The students rated their knowledge and their enjoyment of mathematics and computer programming.

Collectively, the multiple data sources provided a means to triangulate the data. Furthermore, having long-term engagement with the participants, the school site, and collaborating with an interdisciplinary team helped establish the trustworthiness of our study (Erlandson et al., 1993). Additionally, we addressed a topic that is a noteworthy contribution to the field and attends to ethical considerations with meaningful coherence between the literature and the findings (Tracy, 2013).

Ethical Considerations

Given that this study focused on participants who were predominantly minors, the researchers obtained consent from the parents and assent from the students. This process was explained in English and Spanish to the parents and the students during an orientation session for the after-school program. Parents and students were given the option to be video recorded or not, and for their video, images, and student work to be included or not in presentations and publications. To protect the participants' identities, we used pseudonyms. Only research team members who had undergone professional learning with research related to human subjects were allowed to access the password-protected server with the data.

Data Analysis

To analyze how translanguaging practices facilitated interactions among co-facilitators and peers and how translanguaging promoted the growth of the students' linguistic repertoires, we used open coding for the first phase and thematic analysis for the second phase (Saldaña, 2021). In the first phase, researchers identified video clips that satisfied the following criteria: 1) students discussing computer programming assignments; and 2) instances where the students spoke Spanish while code was being analyzed in English.

Each researcher individually open coded using the transcripts that were pertinent to the theoretical framework, then collaborated and agreed on final codes. As researchers, we understand coding is not a precise science; it is primarily an interpretive act (Saldaña, 2021). Our goal was to discuss the codes until we were able to streamline them into an agreeable code. After open coding, subsequent line-by-line close readings resulted in chunking (Saldaña, 2014) based on particular translanguaging aspects such as facilitator stance, co-facilitator language shifts, student language shifts, language labeling, and clarification. During this second phase of coding, theoretical code memos were used to connect ideas. This process permitted us to make comparisons that encompassed the complete data set, continuing with the systematic process in the analysis of the data while developing the emerging themes. Overall, the outcome of the data analysis yielded answers to the research question related to the translanguaging practices among emergent bilingual students in an after-school coding program.

In the following section, we show findings that emerged showing translanguaging practices where the Python code was in English; however, Spanish was used by the facilitator, co-facilitator, and students to understand the code through 1) more than translation/deciphering, 2) negotiating meaning, and 3) language brokering.

Findings

Translanguaging as an analytical lens focuses on language behavior and meaning-making. To teach emergent bilingual students, "...teachers must take up a translanguaging stance, [and] shed their authoritative position" (García, 2017, p. 22). The communication between the participants was analyzed not simply as a language choice but more so in terms of how the facilitator, co-facilitator, and the emergent bilingual students used their home language to make sense of code written in English. In the following findings, we show how the group applied translanguaging to understand the concept of Loops.

More than Translation: Deciphering

Juanita as the co-facilitator used both Spanish and English in her instruction, including different dialects and/or styles (Phillips Galloway et al., 2020) that were necessary to communicate computer programming concepts. Although students may not be aware of it, knowing more than one language can cause a loss in translation mishap. For example, using a word with a similar sound in the wrong context is referred to as a malapropism, which often results in a nonsensical, usually humorous utterance, as noted below:

Juanita: *Ahora vamos a andar enseñando, aprendiendo del For Loop.*
[Now, we are going to teaching, learning about the For Loop.]

Josefina: ¿For Loop?

Tina: *¿Qué no es un cereal?*
[Isn't that a cereal?]

Josefina: Forty?

Tina: *Espera, ¿*Fruit Loops*?*
[Wait. Fruit Loops?]

Vicente: *¡No es un cereal! No manches* (Laughing)
[It is not a cereal! Come on.]

Josefina: *The* Fruit Loops *es un cereal.*
[The Fruit Loops are a cereal.]

Vicente: *¡No! Es For Loop.*
[No! It's a For Loop.]

Vicente clearly thinks the comment about the Fruit Loops is absurd. He understands the notion of Fruit Loops not being part of the computer programming world. Vicente uses pragmatics, or the ability to understand words in multiple contexts, and the assumptions others are making (Hutahaean, 2020; Levinson, 1997). In this instance, the students use their social context and linguistic knowledge purposefully to construct knowledge (Masaeed, 2012) by deciphering the meaning in a humorous way and co-creating their multi-world environment. In the same conversation, Vicente says, "No manches" which translates to "Do not stain." However, the students understand this colloquial cultural meaning as "You got to be kidding me." Most people outside the students' culture would not understand the common phrase in a Spanish-speaking household of Mexican descent. The context of an after-school programming class, where the focus is on teaching emergent bilingual students how to code, also invites interceding cultures.

Translanguaging is a tool for constructing meaning and conducting authentic interpretations (Espinosa et al., 2021). Both the listeners and the speakers must understand the relevance of dialogue in specific learning spaces. In this case, the students were deciphering the words 'For Loop.' Juanita, as the co-facilitator, did not intercede in correcting Josefina, but instead acted as an interlocutor when she allowed the group to use their translanguaging skills to resolve the mishap. While an honest misunderstanding invites the help of a mediating interlocutor (García & Kleifgen, 2020), Juanita knew this was not the situation at hand.

As the instruction of the For Loop continues (Figure 1), we noticed Juanita's confidence with translanguaging; however, we cannot dismiss Fu as the facilitator of the group. Fu speaks very little Spanish but demonstrates her willingness to practice language flexibility by incorporating Spanish words into the coding instruction so students can decipher meaning (Figure 2). However, Juanita understands language is action and practice (Lasagabaster & García, 2014). As Juanita attempts to teach the commands, **start_1, step_1, and stop_1**), she notices how the students spell out the letters in the code **step** in Spanish, ***/ese/ /te/ /e/ /pe/*** to try to make sense of the coding command: **step_i=2**.

Figure 1
Counting Loop

```
# PRACTICE CELL A: Write the code to count from 1 to 10
# Your code should output: 1, 2, 3, …10.
# Use the code above as a guide to create your commands. Be careful about what you
type.

start_i = 1   # Define initial value. Value to start counting.
step_i = 1    # Define the value to count by (or add) after the initial value.
stop_i = 10  # Define value to Stop.
# for is a loop command:
for i in range (start_i, step_i, stop_i):
    print (i)
    # print  (i) needs to have space before writing it or be indented.
1
2
3
4
5
6
7
8
9
```

Juanita recognizes that the pronunciation of letters is not enough for the students to understand the concept and opts for Fu's facilitation with the translation of the code into Spanish: ***el paso*** (the step) to assist students in deciphering the meaning of the command.

She then points to the code: **start_1, step_1, and stop_1** (Figure 1) with the following explanation: "*tiene el empezar, el siguiente, y cuando termina*" [It has the start, the step, and when it ends]. Juanita had previously told them the word "step" meant *el paso* [the step], but now in the line of code, Juanita tells the group, "step" means *el siguiente* [the next number]. The ability to alternate between the language for input and output goes beyond translation but is the understanding of multiple contexts (Baker, 2003, 2011; Williams, 2002). In early language acquisition in bilingual contexts, children learn to associate target words within a specific context but, as they get older, they become aware of the pragmatics or the various meanings of words dependent on context. Fu places the word *el paso* [the step] (Figure 2), modeling a form of translanguaging by willingly translating coding commands from English to Spanish. Translanguaging is more about the kind of context in which the conversation occurs (Baker, 2011). For Juanita, it is about explaining the computation, not the direct translation of the English words to Spanish.

Figure 2

Spanish Counting Loop

```
# PRACTICE CELL A: Write the code to count from 1 to 10
# Your code should output: 1, 2, 3, …10.
# Use the code above as a guide to create your commands. Be careful about what you
type.

empezar_i = 1   # Define initial value. Value to start counting.
paso_i = 1      # Define the value to count by (or add) after the initial value.
parar_i =10     # Define value to Stop.
# for is a loop command:
for i in range (empezar_i, paso_i, parar_i):
    print (i)
    # print  (i) needs to have space before writing it or be indented.
1
2
3
4
5
6
7
8
9
```

Encouraging students to use their home language as a scaffold for learning new concepts is a translanguaging practice that goes beyond translating. Fu and Juanita change a few words in the code to help the students understand the commands, but they are not translating all of the code. Fu is aware that she needs to give the students just enough for them to be able to decipher the code on their own, which requires teachers to see themselves as co-learners with students (Garcia & Wei, 2014). Both languages are present in the coding exercise (Figure 2), which students use to decipher the message or code to be able to understand the concept of range and Loops.

Negotiating Meaning

One of the tenets of translanguaging is capitalizing on students' home language as a lifelong asset. The use of translanguaging affirms the ideology of not wanting emergent bilingual students to stop using their home language (García & Wei, 2014; Makalela, 2015; Mgijima & Makalela, 2016). In the following example, Juanita, as a lifelong bilingual, uses her Spanish to explain code that has been written in English (Figure 1); however, she allows the students to use their Spanish to make meaning of the Loop, as shown below.

Juanita: *Va a empezar con uno y va a ir por uno y luego va a llegar hasta el diez. (pointing to the code written in English)*
[It will start with one and it will increase by 1 and then go up to ten.]

Vicente: *A ver, empezar por uno.*
[Let's see, it will start with one.]

Tina: *Va a empezar con uno, va a seguir por uno, y va a terminar en diez.*
[It is going to start with one, it will continue with one, and finish with ten.]

Vicente: *¿Y va a terminar en uno?*
[And it will end at one?]

Ariel: *¡Diez!*
[Ten!]

Juanita: *So, con For Loop lo que va a hacer va a empezar con el uno.*
[With the For Loop what it will do is start with one.]

Y luego va a ir por unos pasos so, va a ser uno, uno.
[And then it will go in steps, so, it will be one, one.]

Ósea uno, y luego va a ser uno más uno, que es dos, y luego tres, y cuatro.
[So, one, and then one plus one, which is two, and then three and four.]

Va así, pero solo para en nueve porque para un número antes de diez.
[It goes like this; it only stops at nine because it stops before ten.]

The decision of Juanita to point to the code in English (on the computer screen) and use her Spanish to explain the Loop is a pedagogical approach that views language as a dynamic, fluid resource (Lasagabaster & García, 2014). Juanita is continuously using both her English and Spanish linguistic abilities to teach students to negotiate meaning and comprehend effectively (García & Lin, 2016). Fu is also actively involved in the students' learning by listening in and making sure to guide Juanita to check for students' understanding of complex concepts as seen below.

Fu: Tell them to get to fifty. (Talking to Juanita)

Juanita: *Okay, agarren hasta el cincuenta.*
[Okay, get to 50.]

Vicente: *¿Del cinco hasta el cincuenta?*
[From five up to fifty?]

Tina: *Mueve los números, Vicente… y Josefina checa*.
[Move the numbers, Vicente…and Josefina you check.]

Josefina: *Okay, ahora ponle el cinco.*
[Okay, now put a five.]

Tina: *¿Y qué vas a poner en parar, Vicente?*
[And what are you putting to stop, Vicente?]

(Vicente writing the number 50 after the **stop**_i command)

Ariel: *¡Córrelo!*
[Run it!]

The students seem to understand the purpose of the **start_i** command. They also seem to understand how entering a five into the **step_i** command will produce a sequence of numbers in increments of five. However, the students entered a 50 in the **stop_i** command (Figure 3), producing a list that ended in the number 45.

Figure 3
Integers in a For Loop - 1st attempt

```
start_i = 5   # Define initial value. Value to start counting.
step_i = 5   # Define the value to count by (or add) after the initial value.
stop_i = 50  # Define value to Stop.
# for is a loop command:
for i in range (start_i, step_i, stop_i):
     print (i)
     # print  (i) needs to have space before writing it or be indented.
5
10
15
20
25
30
35
40
45
```

Juanita continues to guide the students in rewriting the code as they have produced the incorrect Loop. In the following excerpt, Juanita instructs the students to understand the connection between the **step_i** command and the **stop_i** command:

Juanita: *Okay, va así…para en cuarenta cinco porque para cinco números antes de cincuenta. Entonces, ¿qué número deben poner?*
[Okay, but it goes like this… it stops at forty-five because it stops five numbers before fifty. So, what number should you write?]

Vicente: *Empieza con cinco.*
[It starts with five.]

Juanita: *Y pasa en cinco, entonces…*
[And it goes by five, so…]

Josefina: *Okay, ahora ponle el cinco.*
[Okay, now put a five.]

Vicente: No me desconcentres.
[Don't make me lose concentration.]

Ariel: *Pero tiene que ser hasta los cincuenta.*
[But it must be up to fifty.]

Vicente: *Ahí está.* (Vicente writing the number 51 after the **stop_i** command)
[There you go.]

Juanita applies her linguistic assets (García-Mateus & Palmer, 2017; García & Wei, 2014) to explain the code in Spanish while pointing at the code in English. Juanita's translanguaging allows her to assist students in negotiating the meaning of the **stop_i** command to produce the correct Loop (Figure 4).

Figure 4

Integers in a For Loop - 2nd attempt

```
start_i = 5   # Define initial value. Value to start counting.
step_i = 5   # Define the value to count by (or add) after the initial value.
stop_i = 51  # Define value to Stop.
# for is a loop command:
for i in range (start_i, step_i, stop_i):
    print (i)
    # print  (i) needs to have space before writing it or be indented.
5
10
15
20
25
30
35
40
45
50
```

The students are able to construct new meanings (García & Wei, 2014) and modify the **stop_i** command to get the correct result because Juanita was deliberate in using the students' home language as a resource (Ruiz, 1984), as well as the students' linguistic identity (Wei, 2011). Juanita demonstrates strong bilingual skills, reminding us how even when emergent bilingual students have acquired English at an advanced level, emergent bilinguals should be able to use their full linguistic repertoire as a natural everyday skill. Emergent bilinguals use their languages as a fluid and strategic tool for learning, but also as a form of communication, as shown in the next finding.

Language Brokering

As noted in the two previous findings, one of the core tenets of translanguaging is the concept of flexible language practices, emphasizing the dynamic and strategic use of all linguistic resources available to bilingual speakers, rather than viewing languages as separate entities. This is especially an incredible feat for Fu, the facilitator of the group. Fu is an English Learner whose home language is Vietnamese and identifies as a beginner in knowledge of Spanish. However, she is not hesitant in using her Spanish in teaching one of the most complex Loops (Figure 5), the if elif else Loop,

Fu: *¿Qué es el número secreto?*
[What is the secret number?]

Josefina: *Cinco.*
[Five.]

Ariel: *Porque número (*Pointing at # Number(s)).
[Because number]

Juanita: *No, ¿Por qué ella puso 200?*
[No, why did she put in 200?]

Figure 5
if elif else Loop

```
number = int ("Pone tu número")

secret_number = 5
if (secret number > number):
  # Number(s)= ??? will execute the code below.
  print ("A") #FIX the message
elif (secret number < number):
 # Number(s)= ??? will execute the code below.
  print ("B") #FIX the message
else:
  # Number(s) = ??? will execute the code below.
  print ("C")
  print ("End of the game!")

Pone tu número 200
B
End of game!
```

First, Fu approached the students' learning using the students' home language by writing some of the instructional code in Spanish: "pone tu número." Committed to students' learning, Fu is able to apply her beginning knowledge of Spanish to assist students in grasping the meaning behind the command **secret_number**. However, Fu does rely on Juanita as a language broker (Esquivel, 2012; Orellana, 2009; Tse, 2014) to interpret and mediate:

Fu: If the secret number is 5 and is not more than 200, then you are going to skip it. Is it less than that? (Pointing to the 200) Then, it will print B, and it did print B.

Juanita: *Ahora lo que pasó es que el número secreto era cinco, ¿verdad?*

[What happened is that the secret number was five, right?]

Y el número que Josefina puso era 200 y el número secreto no era más grande.
[And the number that Josefina put was 200 and the secret number is not greater.]
(Pointing to the command (if (secret number > number)

Entonces se movió hasta el siguiente.
[So, then it moved to the next one.]

Vicente: *¡Oh!*

Ariel: *Es cinco.*
[It's five.]

Juanita: *Sí ¿Entonces el número secreto es más grande que doscientos, o no?*
[Yes, so is the secret number greater than two hundred, or no?]

All: *¡No!*

Juanita: *Entonces va al siguiente paso porque no es el primero.*
[So, it goes to the next step because it is not the first.]

El número secreto es más chiquito que el número doscientos. ¿Verdad?
[The secret number is smaller than the number two hundred. Is that true?]

Ariel: *Si.*
[Yes.]

Juanita: *Entonces B.*
[That is why B.]

Juanita conciliates between Fu and the students rather than merely transmitting information, demonstrating how language brokering enhances problem-solving skills. Facilitating between two languages is not a simple cognitive or linguistic task of decoding, it requires the application of other knowledge to extract meaning from the words and context (Barac & Bialystok, 2012). In the case of Fu, she is able to apply the knowledge and context of computer programming:

Fu: *Cinco es más grande que dos… (pointing at the computer screen)*
[Five is greater than two…]

Vicente: *…cientos.*
[...hundred.]

Fu*:* *Sí, entonces no A.*
[So, then not A.]
(Looking over at Juanita) How do you say… this is wrong?

Juanita: *Porque está mal.*
[Because it is wrong.]

Fu: *Sí, está mal, entonces aquí cinco es menos.* (pointing to the code in English)

[Yes, it is wrong, so here five is less.]

Juanita: *¿Cinco es menor que doscientos?*
[Five is less than two hundred?]

Fu: *¿Sí o No?*
[Yes or No?]

Ariel: *Sí.*
[Yes.]

Fu: *Entonces B*
[So, then B]

Both Fu and Juanita used Spanish and English to shape students' knowledge (Swain, 2006) in the STEM area, where English is normally the language of instruction (Kleyn & García, 2019); however, Juanita as the language broker is the bridge that facilitates the communication gaps. Although neither Spanish nor English are Fu's home language, she is committed to demonstrating how her linguistic resources are valid for teaching and, most importantly, how translanguaging can be used as a pedagogical tool in teaching emergent bilingual students.

Discussion and Implications

In our study, we aimed to show translanguaging as an inclusive instructional practice in an after-school program that integrated mathematics and computer programming. Our study contributes to the fields of bilingual and STEM education in that there is a paucity of studies that investigate the intersections of translanguaging and computer programming with multilingual learners.

Our overall findings are in line with previous research, showing that emergent bilingual students draw on multimodal and multilingual contexts for meaning-making (Celedón-Pattichis et al., 2022; Marshall et al., 2023; Pierson & Grapin, 2021; Vogel et al., 2020), indicating that being multilingual is an asset for better understanding STEM concepts. As illustrated in the excerpts, the facilitator and co-facilitator played a critical role in using language brokering that created a space for multilingual learners to thrive, inviting emergent bilinguals' linguistic repertoire into the space and understanding the context in order to extract the meaning. In this case, the students adapted and adjusted their interpretation into the context of computer programming. Most importantly, these findings advance knowledge on how students can draw from their full linguistic repertoire to decipher and make meaning of some of the most fundamental concepts (e.g., conditional statements and Loops) in computer programming languages written in English.

García and Wei (2014) remind us of the importance of putting emergent bilingual students' home language alongside the majority language to counter deficit notions of using only one language to make sense of new concepts. In the after-school program, the students' home language was invited into the learning space to assist in analytical thinking, collaboration, and computational thinking. A translanguaging pedagogy requires teachers to be comfortable with translanguaging in the classroom (García & Lin, 2016). As evidenced in the excerpts, the facilitator and co-facilitator, as teachers, modeled flexible language practices as a tool to enhance, decipher, negotiate, and code in a computer programming language.

Conversely, we noted the positive ambiance in the learning of the students. During the exit interviews, the students shared how being allowed to speak in Spanish or English helped their understanding of computer programming, resulting in increased interest in STEM (LópezLeiva et al., 2022), affording emergent bilingual students opportunities in STEM, a field with underrepresentation of Latine in the United States (Hernandez Negrete et al., 2023). As Potowski (2004) states, language is "best learned as a medium of content rather than as the focus of instruction" (p. 95). For K-12 education, translanguaging implies affording emergent bilingual students' opportunities to leverage their entire linguistic repertoire to build communication skills and enhance their understanding of complex scientific concepts, leading to increased engagement and deeper learning. In all, translanguaging in an after-school program brought increased engagement in a welcoming learning environment where students were able to express themselves authentically and make meaning of fundamental programming concepts, which is no small feat for multilingual learners without prior experiences in computer programming.

Acknowledgements

The research reported here was supported by NSF Grant Numbers 1613637 and 1949230. Any opinions, findings, and recommendations expressed are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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