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Middle School Engineering Teachers' Enactment of Pedagogies Rooted in Funds of Knowledge and Translanguaging: A Comparative Case Study (Fundamental)

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Several decades ago, Vélez-Ibáñez and Greenberg[1,2] developed the concept of funds of knowledge to highlight the assets that Latinx children bring to educational settings. Funds of knowledge refer to the "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning" (p. 133).[3] In their seminal work connecting household funds of knowledge to education in elementary schools, González and colleagues[4] described how teachers visited students' households to build relationships and learn more about familial practices, and how they subsequently developed curricula that connected these practices with educational standards.

In this work, during her home visits, elementary teacher Ms. Amanti observed fifth-grade Carlos selling candy, and she learned of local parents' skills in making candies. She used this knowledge as the basis for a student-driven curricular unit in which children posed questions about candy, such as "What ingredients are used in the production of candy?" Students answered this question by graphing the frequency of occurrence of the ingredients they found in Mexican and US candy samples, while parents served as core intellectual resources who demonstrated how to make candy and who shared other types of knowledge, such as differences in US and Mexican food consumption and production.[3]

Since this early work in funds of knowledge, dozens of articles have further illustrated the promise of pedagogies that foreground youths' funds of knowledge across grade levels and disciplines.[5] In recognition of this promise, many prominent educators and educational theorists have asserted that funds of knowledge pedagogies can be vital to advancing equity by foregrounding and sustaining youth cultures, thereby countering deficiency models of education.[6] However, while funds of knowledge pedagogies are widely recognized as advancing educational equity, they remain relatively understudied in the discipline of engineering.[7] Specifically, little research exists on how engineering teachers understand and enact funds of knowledge pedagogies when working with Latinx youth.

The purpose of this research was therefore to explore how engineering teachers of Latinx youth understood and enacted pedagogies rooted in funds of knowledge in the context of a multi-year professional development experience. The portraits of these engineering teachers illustrate different possible dimensions and challenges related to funds of knowledge pedagogies in engineering, which can be used as considerations for other engineering educators and professional development providers who seek for ways to ground their curricula and pedagogical strategies in Latinx youths' funds of knowledge.

Funds of Knowledge in Engineering

Based on his work with Latinx families on the US-Mexico border, Moll et al.'s original outline of funds of knowledge included categories such as knowledge of equipment operation and maintenance, market values, building codes, budgets, construction, design and architecture, repair, and ethics.[3] Although Moll and colleagues did not explicitly connect these funds of knowledge to engineering, many of these categories bear direct relevance to engineering

practices, and for this reason, engineering may be an especially promising discipline for foregrounding Latinx students' funds of knowledge.[8] Under this assumption, we conducted a project to better understand the engineering-related funds of knowledge of Latinx youth who had been designated by their schools as 'English learners.'[9] Wilson et al. authored the first publication that stemmed from this work, which outlined funds of knowledge categories such as workplaces; health of self and family; transnationalism or travel across countries; household, construction, and maintenance; popular cultural texts; and digital technologies.[10] The table below illustrates examples from this paper, which illustrates youths' engineering-related funds of knowledge in each category.

Table 1. *Latinx youths' engineering-related funds of knowledge.*

Fund of Knowledge Category	**Illustrating Example from Wilson et al., 2013**
Workplace	Ariana, Isabel, and Sofia's parents worked at meatpacking plants where employers valued profit above worker safety. For example, the company did not pay for additional equipment to help workers lift heavy objects because the equipment was too expensive. Through witnessing their parents' workplace injuries, they developed a deep sense of the importance of ethics and value judgments in engineering and the importance of valuing people above profit. These guiding values helped them prioritize trade-offs when designing devices for people from minoritized groups.
Health	Tito helped his younger brother with muscular dystrophy get in and out of a shower chair because his mother did not have the muscular strength required to do so. He used this experience to design a shower chair that could by used by caregivers with a wider range of body types.
Transnationalism	Karina helped her father design a house for her grandmother in El Salvador. She explained how differences between the two locations (El Salvador and her current location in the US) resulted in the selection of different materials and design features.
Household/yard care and construction and maintenance	Elena helped her father lay stones in the backyard outside their porch to prevent erosion. They used this knowledge to design a playground with features that prevented erosion. Silvia watched their data install metal fence and gates. She knew he had experience with metal working and asked for his expertise when choosing a metal for a cat restraint device she designed.
Popular Culture	Eduardo watched *Design Squad,* a show on PBS that featured diverse youth solving different problems through engineering via a process of considering the merits and drawbacks of each potential solution.

Digital technologies	Silvia played with fashion apps in which she read clients' specifications and made designs that met those specifications. She also looked at the clothes that the client had worn in the past, noting the materials and colors used in those clothes. She used this material to fashion designs that were desirable to clients. This skill is relevant to engineering as engineers consider clients' specifications when planning designs.

Later publications from this project expanded this work by elaborating on these findings and exploring other facets of Latinx youths' funds of knowledge,[11] for example, by focusing primarily on funds of knowledge obtained in the context of workplaces.[12]

Other scholars have offered different frameworks for understanding engineering-related funds of knowledge. For example, building from Smith and Lucena's research on first-generation, low-income undergraduate engineering students,[13, 14] Verdín et al. created and validated survey measures to identify the funds of knowledge of engineering undergraduates.[15] Their funds of knowledge themes included drawing from students' home environments to scaffold engineering learning; tinkering knowledge; perspective taking; reading people; mediational skills; and community networks.

While these categories of funds of knowledge are useful, few studies have applied these categories by illustrating how engineering teachers can build from funds of knowledge as they enact assets-based learning approaches for Latinx students. In our current project with middle school engineering teachers, we used these initial frameworks of funds of knowledge as heuristics for considering the possible types of engineering-related funds of knowledge that Latinx students might hold, while also affirming the imperative for educators to recognize the diversity of Latinx communities and to develop partnerships that foreground local community knowledges and resources.

Funds of Knowledge and Translanguaging

Although the aforementioned previous descriptions of funds of knowledge did not address multilingualism, other writings by Moll foregrounded the role of bilingualism as a vital resource in learning for many Latinx youth.[16] If schools and educators embrace the ethical imperative to sustain rather than erase minoritized students' home cultures, then sustaining home languages is vital to education in a democracy.[17] Accordingly, translanguaging has gained prominence as an important approach across academic disciplines.

Translanguaging is based in the principle that multilingualism is a resource for learning, doing, and imagining at all times.[18] In translanguaging classrooms, educators seek to leverage students' full linguistic repertoires. They provide multimodal and multilingual resources as students work in purposefully planned collaborative/juntos structures wherein they have opportunities to speak their home languages with others.[19] Translanguaging is thus consistent with funds of knowledge pedagogies in the sense that translanguaging pedagogies seek to explicitly sustain home cultures and foreground students' existing resources—in this case, their languages.

Translanguaging pedagogies challenge the idea of 'levels' by recognizing that each student possesses a distinctive linguistic repertoire that can be leveraged in the classroom as they have opportunities to speak, read, write, listen, and learn with others.[18] This approach requires teachers to be flexible and to follow the language corrientes that emerge in multilingual classrooms as students speak, listen, read, and write in multiple languages and hybrid languages with each other.

Research Question

Given this background, our study seeks to answer the following research question: How do middle school technology and engineering teachers enact pedagogies rooted in funds of knowledge and translanguaging?

Context of the Study

To answer this question, we conducted a comparative case study of two middle school technology and engineering teachers who taught in two school districts in the Western United States. Alex described himself as a 'Hispanic male' and taught a mandatory Technology and Engineering class in a middle school in which 62% of the students were Latinx. Alex further described his school: "In the school, historically we've struggled with a lot of disparity in socioeconomic opportunity." We observed Alex's class over seven trimesters; for the trimester that we describe in this paper, he reported that one third of the students in his class were currently receiving English as a Second Language services, and most of the students in his class were bilingual or multilingual.

Alex wanted to become a Technology and Engineering teacher in part because his father was an engineer in Mexico, and he wanted to inspire other youth to consider similar fields. Alex had also lived for several years in Peru. To pursue his life-long interest in Latin cultures, he had taken several Latin American studies courses in college as an undergraduate. He lived in a different city from his students, but at the time of the study, he had taught in the school for ten years and was known as a passionate advocate for Latinx youth.

Andrew, who identified as a 'white male,' taught a mandatory Technology and Engineering course in a middle school in which about 40% of the students were Latinx. He further described his school as, "We have about a 22% mobility rate. One out of four of the kids are gone and new kids have replaced them." We observed Andrew's class over five trimesters; for the trimester that we describe in this paper, he reported that one student in his class was receiving English as a Second Language services, although over one third of his class was bilingual.

Andrew had taught in the same school for decades and grew up in the same town as his students. He described his experiences growing up: "My background was I worked at a dairy. We drove tractors when we were 11. They put us in trucks. We were shifting and operating the clutch. We went through the process of making mistakes. We dumped hay bales over." Over the summers, when he was not teaching, he described how he sought to "build that relationship" with different

community stakeholders, such as industries and educators at the local technical college, in order to better support his students' career pathways in the community.

Although González and colleagues recommended that teachers visit students' homes to learn about their funds of knowledge,[4] both teachers worked in school districts whose policies prohibited middle school teachers from visiting students in their homes. Given this constraint, Andrew and Alex both participated in a multi-year professional development project in which they read articles about pedagogies for linguistically diverse students, including funds of knowledge pedagogies and honoring and incorporating students' home languages and linguistic repertoires through using strategies recommended in translanguaging approaches. They also observed other teachers as they taught in ways designed to foreground students' funds of knowledge and home languages. For over one year, they participated in ongoing professional development in which they reflected on student work or transcripts of their own teaching and discussed and identified ways for better supporting Latinx students who were receiving ESL services.

Methods

For the trimester reported in this comparative case study, we observed each teacher daily for a minimum of four instructional units. These instructional units were each comprised of one engineering design challenge and ranged from a few days to a few months in duration. This study also draws from four interviews per teacher, which were designed to better understand why they made pedagogical decisions.

We conducted inductive thematic analyses of these interviews and observations to explore the ways in which each individual teacher enacted funds of knowledge pedagogies and translanguaging pedagogies. Specifically, we discussed individual excerpts of data and developed themes based on these excerpts for each individual case.[20] We then conducted a cross-case analysis by identifying similarities and differences across cases. The themes that we identified represent ways in which the teachers sought to enact funds of knowledge pedagogies; each theme is indicated in italics below.

Findings: Alex and Andrew

The findings from the thematic analysis indicated similarities and differences between how Alex and Andrew enacted funds of knowledge and translanguaging pedagogies, which we elaborate more on below.

Selecting Contexts for Engineering Design Challenges

Both Andrew and Alex sought to foreground students' funds of knowledge through co-selecting engineering design challenges with students, and/or through selecting engineering design challenges they believed were likely to leverage local community knowledge. As much as possible, they sought to contextualize their instruction within 'real' engineering design challenges that enabled students to address actual issues faced in the community and that enabled students to develop and communicate solutions that could actually be implemented.

For example, Alex worked at a middle school that was relocating to a new building. In response to a petition put forth by some of Alex's students, the district superintendent agreed to have a community garden at the school. Alex's students were responsible for designing the garden. In his words:

> In my sixth grade class, we're preparing to have a community garden at the new school. What's going to be grown? And what kind of responsibilities going forward do you think the people will need to know about? Like cleaning, planting, harvesting, selling. Are we gonna sell it? Are we gonna donate it? So there was an open-ended question is what are we gonna grow? Where are we gonna grow it? What are we gonna do with all the food? And so we've been wrestling with those questions that are still not defined. …I was suggesting the foods that you see locally, that are grown locally rather than try to greenhouse them, so the seasonal crops that are typical for our area. And honestly I have not read all of what they've produced, but what I did note was that they were very active on their research.

The students conducted Internet research in their home languages and English in order to learn more about local fruits and vegetables they might grow in their garden. Additionally, they talked with their parents and family members in both their home languages and English to learn additional ideas about where they should place their garden and the individual plants within it, what they should grow there, and how they should care for the plants. Alex further explained:

> We're promoting that garden and so we're using our business and marketing knowledge skills to inform, at this point, people have been persuaded that this is a good thing, so now their job is to inform the public that we will have a garden. So we've talked about the stakeholders, the parents, the students themselves, the administrators and so they've created posters, flyers and other formats of advertisements.

Andrew, too, sought to foreground students' funds of knowledge, first, by co-selecting local problems with students and/or by grounding engineering design challenges in local contexts. As an example, most of his students reported problems with congestion and safety issues beside their school, so they identified solutions for improving traffic flow. Andrew encouraged them to interview parents, peers, and teachers in multiple languages to collect information about the problem, and/or to collect data through other means (e.g., photographs from cell phones). In his words:

> And Eduardo said, my mom can get this stuff for us. He was involved, so he went to the only person he knew that could help solve his problem and he did a little research. He started off with his mother, that's a great place to start. So it was very good.

A parent visited Andrew's classroom and shared what he knew about the site's economic constraints for the students' further consideration. Andrew's students then developed solutions to the problem of traffic congestion and presented them to a committee that included local parents and the principal.

In both of these cases, common themes emerged. First, where possible, the teacher's selection of the engineering design challenge was *driven by student interest* and *was contextualized within the community*. Additionally, the teachers *positioned parents as core intellectual resources* by inviting them to the classroom and/or by encouraging the students to learn from their expertise as they gathered information about the design. Finally, the teacher encouraged the students to share their proposed solutions with *real audiences*.

Promoting Bilingualism

In accordance with recommendations for translanguaging pedagogies, Alex and Andrew regularly provided multilingual, multimodal resources for their students. They showed pictures of words that represented core vocabulary words with examples of the words in Spanish and English. They also provided bilingual resources for engineering design challenges, such as providing data or informational materials related to the engineering design challenges in Spanish and English. However, although both teachers provided resources for receptive bilingualism (e.g., multilingual texts), only Alex's class regularly engaged in expressive bilingualism through writing and speaking.

Both teachers sought to foreground students' funds of knowledge through the selection of engineering design challenges and through positioning students as experts, but they also enacted different pedagogical strategies for encouraging and building from their funds of knowledge. We elaborate on differences between the two teachers' funds of knowledge pedagogies and translanguaging below.

Findings: Alex

Sharing and Encouraging Narratives

Alex's school required him to teach a medical technology and engineering unit. In this unit, he gave students bones from turkeys' legs from a butcher shop. Students used lab equipment to break these bones, which bore some similarities to human bones. Then, given the unique nature of each break, students worked in collaborative groups to engineer a way that they could keep the bones stable and help them heal. To scaffold this process, Alex shared different medical technologies and techniques that are used to treat different kinds of breaks in the US, such as rods and screws.

However, he also encouraged students to draw from their family's knowledge of healing as they considered how they would treat the patient with the broken bone. He then told a story, drawn from his experiences in Peru, in which he "entered the home of a man who was bedridden." Specifically, he described a man who:

> Needed his bone fixed from the outside of his leg. This gentleman had the framework on the outside of his log, holding it together while the bones were growing together and that it required a lot of healing time. And he went to his local healers, and the belief was that the tree sap from a parasitic tree, which wrapped itself around the other trees, would do

> the same to his leg. The healer prepared a concoction that he would drink, and his belief was that the sap would behave the same way in his leg.

In this narrative, the man's leg healed due both to the external framework on the outside of his leg, as well as his confidence in the healer and the care provided to him by his family and a caring community. After sharing his own story with providing healing care to his bedridden neighbor, Alex encouraged his students to share their stories of healing with their families and to consider how these stories of healing might inform their solution for healing the broken leg.

His narrative-based approach validated students' knowledge of folk medicine (a category of funds of knowledge initially outlined by Moll) and encouraged them to use this knowledge to inform their solutions to healing the hypothetical patient with the broke leg similar to the turkey bone, while still meeting school expectations of introducing students to medical technologies.

In-the-Moment Decisions to Follow the Translanguaging Corriente

In addition to providing bilingual Spanish/English resources, Alex often walked around to different groups as they were developing solutions to engineering design challenges, and he had different interactions with groups depending on the languages they were speaking. As he circulated the room, he frequently talked one-on-one with students in ways that honored their home languages and that encouraged them to use multiple languages in class. For example, he paired a fluent Spanish speaking student with Gabriela, a student who had recently enrolled in the class after moving from Mexico, because he thought they might be friends and that they could work productively together in addressing design challenges. He described his interactions with Gabriela during one moment in class:

> I asked her in Spanish. She answered in Spanish. Then I asked the same question in English and then answered in English for the class. It's [speaking Spanish] is really really helpful for me. Then when I have students from the Middle East who speak Farsi or Afghanistan, who speak another language…while I'm not able to provide those types of literature that are in their first language, I find myself trusting on their resiliency. I might provide an organizer, or…say, 'Respond in your native language. Express, interpret for me, what you read.'

While he provided bilingual materials in Spanish and English, he stated that his greatest challenge as a teacher was not having enough time to plan and find helpful materials for all of his students. At the same time, while he was unable to locate multilingual materials for the multiple languages spoken in his class, he demonstrated that he valued students' home languages. He honored multilingualism through speaking Spanish and through asking students who spoke other languages to teach him words in those languages. When students submitted assignments in their home languages, he met with them to understand what they were saying and to write parts of the assignments in English "as they are able."

His approach to language in his classroom indicated that he often made in-the-moment decisions to speak Spanish, English, or a combination of these languages in speaking and writing as he placed his students in carefully-selected groups based in part on language considerations. He also

had individual conversations with students who spoke a range of languages, sought to learn words in those languages, and encouraged them to write in those languages, even when he could not provide reading materials in those languages.

Findings: Andrew

Experiential Learning in Place and Popular Culture

Andrew had a deep knowledge of many landmarks in the town in which he and his students lived. One of his phrases that he used to describe himself was "when you're local…" He described his teaching philosophy as being tied to experiential learning. He explained that when concepts were too abstract, then his students "don't have any basis to relate to" them, but when "they were experiencing it, it gave more success that way."

Accordingly, several of his engineering design challenges were associated with local places. He took his students outside to observe, discuss, and share their experiences with the places; he also encouraged students to take photographs of each place and to learn of other people's experiences with each place. He also used local landmarks, close to the school, as topics for critique and discussion, such as "why they put roundabouts instead of a stop light or why Walmart is located where it's at."

Aware that he had held occupations in the community that shared similarities with some of his students' parents, he taught a workplace safety unit in which students designed safety procedures for a workspace. Andrew asked them to draw from their own experiences in working alongside their parents, or to draw from the stories their parents had told them about their workplaces, to better understand the different workplace hazards that might occur and to develop procedures for avoiding them.

Finally, Andrew regularly brought blockbuster movie clips into his classroom, or used high-interest popular cultural events (e.g., the engineering of the Superbowl stadiums), as another means of connecting students' popular cultural knowledge to engineering. In his class, students shared what they learned from movies, TV shows, or popular events and Andrew asked them to draw parallels between the character's actions and those of engineers.

In all, Andrew sought to ground several engineering design challenges either in students' or their *family's experiences in local places*, as a potential means of foregrounding students' funds of knowledge in the context of design challenges. Secondarily, Andrew believed *using popular cultural texts* as a discussion point would also engage his students more fully in engineering.

Reading But Not Writing in Spanish and English

At the beginning of the study, Andrew had stated that professional developers at his school had recommended: "You make the ESL learners or Spanish-speaking students read English. You're actually hurting them by giving them the Spanish." In contrast to this stance, the professional development provided by this project highlighted multiple advantages of bilingualism, such as cognitive benefits and expanded social networks, in addition to the ethical imperative to sustain

home languages.[21] In the context of the professional development provided by this project, he changed his practices to include providing bilingual Spanish and English materials, but we did not observe students speaking Spanish in his classroom, even in small group settings. Unlike Alex's class, in which a majority of students spoke Spanish, many students in Andrew's class spoke only English. We speculate that this characteristic, in addition to Andrew's monolingualism, made it more difficult to sustain translanguaging in which bilingual students could regularly speak in their home languages. Andrew did not encourage students to submit assignments in their home languages because he could not read their responses, and this would make it more difficult to determine how they were interpreting course content. Additionally, his school had adopted the stance that students should submit assignments in English. These additional characteristics, too, provided challenges to sustaining and encouraging multilingual practices. At the same time, we do recognize that Andrew challenged typical practices at his school by providing bilingual materials to students, and in this way, he affirmed multilingualism.

Implications

This study paints a picture of how different teachers enacted pedagogies, which had the potential for drawing from students' funds of knowledge and languages, in different ways. As a general finding, both teachers considered the context of the design challenge to be a centrally important consideration. Alex's garden design challenge enabled students to draw from familial knowledge related to household and yard management (a fund of knowledge originally identified by Moll and confirmed in later studies). Andrew's workplace safety design challenge likewise enabled students to draw from their workplace funds of knowledge, such as those derived directly from labor histories (a fund of knowledge also identified by Moll and confirmed in later studies). Other pedagogical strategies for incorporating funds of knowledge included encouraging students to share familial narratives or experiences; honoring these experiences and stories by encouraging students to incorporate them into their design solutions; and positioning parents as vital intellectual resources.

While both teachers made moves to incorporate pedagogies that foregrounded students' funds of knowledge as resources for learning, they both found it more difficult to foreground students' languages as core resources for learning. Alex reported challenges in finding multilingual resources for students from the Middle East, while Andrew reported that leadership at his school thought that speaking in Spanish would hinder students' ability to learn English. Despite these challenges, Alex's case provides insights into how teacher stance—including the teacher's attitude toward languages—can encourage students to write, imagine, and learn in their own languages, even in contexts wherein students' linguistic repertoires are diverse and different from one another. Through this stance, and through carefully planning engineering design challenges that have the potential to elicit students' funds of knowledge, engineering teachers can continue to look for opportunities to honor students' cultural and familial resources in the context of engineering.

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