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From Walls to Voices: Art, Mathematics, and the Power of Representation in Schools

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Abstract: This paper explores the intertwined journeys of three women—an artist and Latina, a white ESL teacher, and a Latina mathematics educator—who came together through a shared commitment to reimagining educational spaces. Through personal narratives, we trace how our diverse backgrounds and experiences converged in a collaborative research project that engaged immigrant multilingual students in creating three murals. These murals served as acts of resistance and transformation, challenging the dominant cultural narratives embedded in traditional school spaces and centering the voices and identities of multilingual immigrant students. Our stories highlight the complexities and possibilities that emerge when art, teaching, and mathematics intersect within culturally rich and linguistically diverse contexts. We reflect on how our individual paths—rooted in art, pedagogy, and mathematics education—became collectively powerful, enabling us to create spaces where students could see themselves represented and valued. This collaboration not only reshaped the physical environment but also disrupted conventional notions of who belongs in educational spaces, offering a model for research that embraces relational, embodied, and transformative practices. To further enrich the storytelling and bring these narratives to life, we interweave illustrations throughout the article, visually capturing the themes of resistance, transformation, and representation.

Keywords: Mathematics, Immigrant students, Multilingual, Murals, Collaboration

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The Beginning

The project we discuss in this paper began, as many meaningful collaborations do, with a shared sense of urgency and possibility. It was sparked by an invitation from Higinio Domínguez[1] to join a team of colleagues committed to reimagining mathematics education. In response to his invitation, Carlos LópezLeiva[2] and I (Gladys) joined him in forming a collaborative team, each of us bringing our own questions, commitments, and local relationships to the work. While each team member managed their own site, the project was deeply collaborative. Ongoing dialogue, shared practices, and mutual support shaped it. I am deeply grateful for this experience, and for the learning, collegiality, and friendship that emerged through our time working together. This article reflects that shared history.

Our collaboration was grounded in a collective commitment to honoring the voices, knowledge systems, and lived experiences of the young people and teachers we worked alongside, particularly those from communities historically marginalized in mathematics

[1] He is an Associate Professor in the College of Education at Michigan State University. His post-positivist scholarship challenges Eurocentric traditions in the humanities that privilege rationality and causality over love, reciprocity, and possibility. Through collaborations that engage Indigenous knowledges, feminism, new materialism, and posthumanism, his work seeks to dismantle hierarchical structures in educational research and interrogate representational practices that presume to speak for others.

[2] He is an Associate Professor in Bilingual Education at University of New Mexico. His work bridges classroom practice, community engagement, and critical research in mathematics education. Drawing from his experiences teaching in Guatemala and the United States, he examines the social construction of culturally and linguistically diverse learners and the ways dis/ability and identity are positioned in mathematical activity. His research, grounded in critical and decolonizing pedagogies, explores how bilingualism, ethnomathematics, and practitioner inquiry open spaces for reimagining what it means to teach and do mathematics within and beyond school settings.

education. We envisioned a project that would not only ask what teachers need to know, but also, more radically, how knowledge might be co-constructed between teachers and students through practices of inquiry, creativity, and mutual recognition. Our work was informed by feminist and decolonial scholarship that resists the fragmentation of human experience and instead foregrounds relation, sensation, and transformation as central to processes of knowledge-making (Anzaldúa, 2012; Cajete, 2000; Lugones, 2010; TallBear, 2017)

In dreaming this project into being, we did so with the intention to build theory, not from a distance, but from within the pulse of classroom life through murals, movement, mathematical conversations, comics, shadow puppets, and sock puppets as forms of mathematical expression infused with criticality, transgressiveness, and creativity, and the cultivation of pedagogical intimacy. The proposal we submitted underwent rigorous review, and when funded, was understood to be in alignment with the National Science Foundation's (NSF) own priorities: advancing foundational knowledge of learning in STEM contexts, expanding participation, and supporting the development of a diverse and justice-oriented teacher workforce (National Science Foundation, 2024).

Yet, on April 25th of this year, with no prior warning, our project was terminated under the current national administration. The official reason given was that the project "no longer effectuates the program goals or agency priorities" (J.H. French, personal communication, April 25, 2025), invoking the NSF Grant General Conditions clause on "Termination and Enforcement" (National Science Foundation, 2025). It is hard to describe the emotional weight of receiving such a notice after years of work, planning, and dreaming with teachers and students across three states, especially when the project had only just begun its full implementation.

There is irony here that cannot go unnamed. This project was about mathematics teaching and learning, one of the stated priorities of the federal government (U.S. Department of Education, 2025). More importantly, it was about doing mathematics in ways that center relationality, creativity, and cultural relevance. It aimed to make visible the complex knowledges that Black, Native, Latin@, and newcomer[3] students bring into mathematical spaces, knowledges that rarely find affirmation within dominant instructional models. That such a project could be approved, celebrated, and then erased without accountability or transparency reminds us how fragile and how political this work truly is.

It felt important to begin by naming the shared vision and history that gave rise to this project. Acknowledging my colleagues, Higinio and Carlos, is essential; this work would not exist without the collaborations we built together. Although they are not co-authors of this article, they were instrumental in shaping the foundation of the project we describe here. In the sections that follow, the use of *we* refers specifically to the three authors of this paper. Still, the spirit of this work is deeply rooted in the relationships and commitments we cultivated together from the beginning.

[3] While we use the term here to situate the institutional context of the classroom, we do so critically and with awareness of its limitations. Labels like *newcomer* can flatten the richness of young people's experiences and identities. Throughout this article, our aim is to center the humanity, agency, and knowledge of the students we had the honor to learn alongside.

Theories that Ground our Work and Thinking

Our work is grounded in a shared understanding of teacher learning as a dynamic and relational process that unfolds through encounters between teachers' and students' ways of knowing. Rather than viewing teachers' and students' ways of knowing as distinct or hierarchical, we are drawn to what emerges when they meet, how they move, intertwine, and transform one another. From this stance, learning is not conceived as the acquisition of predefined knowledge, but as the movement of ideas and concepts through relationships, an event in which new meanings, connections, and pedagogical possibilities come into being.

Building on Davis's (2008) conception of concept study—a practice that bridges the analytic depth of concept analysis (Leinhardt, et al., 1992) and the collaborative inquiry of lesson study (Fernandez, & Yoshida, 2004)—our project extends this approach by attending to the liveliness of children's conceptual worlds. The notion of animation guides this extension, inspired by developmental and sociomaterial perspectives that recognize children's engagement with the material world as vibrant and agentive (Piaget, 1929; Aslanian, 2018). In this approach, teachers are invited not only to study mathematical concepts but also to animate them to notice how concepts move, take shape, and acquire meaning through children's embodied, imaginative, and material interactions.

Our orientation is further informed by material feminist and Indigenous knowledge traditions, which position concepts not as static abstractions but as living forces that connect humans, materials, and environments in ethical and reciprocal ways (Barad, 2007; Barad, 2008; Bennett, 2010; Barnhardt, R. & Kawagley, 2008; Cajete, 2000; Tuck & McKenzie, 2015). Drawing on Barad's (2008) metaphor of diffraction—the pattern that emerges when waves meet and generate something new—we conceive of teacher learning as a diffractive process. In this view, teachers' and students' conceptions do not simply coexist or mirror one another; rather, they intra-act to create new forms of mathematical thought and practice.

Our Methodological Approach

Our methodological approach draws inspiration from community-based and participatory research traditions, particularly as articulated in the work of Adams (2021), who invites researchers to approach inquiry *with* rather than *about* communities. Following her example, we understand methodology not as a fixed set of procedures but as an ethical and relational stance, one that unfolds through reciprocity, accountability, and shared imagination.

As Adams reminds us, community-engaged research is a process of *working the hyphen* between researcher and community, teacher and student, artist and participant. This orientation demands attentiveness to power and possibility to how relationships are formed, maintained, and transformed through collaborative action. Guided by this sensibility, our project emerged through a sustained partnership with teachers, students, parents, and a local artist, where decisions about design, process, and meaning were made collectively. The murals that resulted were not simply artifacts of learning but living records of relational work, of care, negotiation, and mutual recognition.

In resonance with Patel's (2016) work, we understand our methodological commitments as inseparable from the histories and communities that hold us accountable. Patel cautions that research itself is a colonial inheritance and calls instead for practices that honor knowledge as relational and situated. We take this seriously: the knowledge that surfaced in this project cannot be disentangled from the people and places that made it possible. Following Patel, we approach

research as a "practice of relation," where the purpose is not to generate data but to deepen our collective capacity to live and learn well together.

This ethic of reciprocity also echoes Kimmerer's (2013) teachings, where knowledge-making is understood as a form of gift exchange, a mutual offering between humans and the living world. Inspired by her call to give back to the world in return for the gifts we have been given, we approached our collaboration as an act of reciprocity. The murals, stories, and reflections that emerged are offerings to the community, created with gratitude and care, and meant to circulate back into the very spaces that nourished them.

Our work was also guided by our desire to describe presence rather than absence (Tuck & McKenzie, 2015). Instead of documenting what communities lack, we attended to the abundance of stories, talents, and cultural knowledge that already thrived among the youth we worked with. Through a reflective dialogue, we all shared our experiences in multiple languages and expressive forms. These stories were not data points to be coded but acts of meaning-making that shaped the project's direction and deepened our relationships.

In the spirit of Kimmerer (2013) and Adams (2021), our analysis was less an act of reduction and more a practice of listening, of returning to each other's words, the murals, and our shared memories with attentiveness and care. Meaning was generated through conversation and co-reflection, in classrooms and on sidewalks. Our methodological orientation positions research as a living practice of relation, one animated by reciprocity, humility, and imagination. It asks not what knowledge we can extract, but what forms of solidarity and renewal can be cultivated through the act of learning together.

Students, Place & Us in Relation to Teaching

The Students

The students who joined us in our collaboration were all connected to Caroline and her role as an ESL teacher at a local elementary school. A total of twenty-one students in grades 2-8 engaged in our work through the NSF grant over the course of the three years. Six students participated in all three murals, three students participated in two murals, ten students participated in one mural, and two students participated during the school year activities and lessons. Fifteen of the 21 students received direct English or mathematics instruction from Caroline; the other six students were welcomed into the project as siblings or close friends of Caroline's students. Caroline taught many other students in addition to the students who chose to participate in the mural projects. Some of those students came and went too quickly to be incorporated into the project; others chose not to participate. The students we talk about in this article are from Central and South America and Central and East Asia. They speak Spanish, Farsi, Pashto, and Mandarin Chinese.

Gladys

I still remember the first day I stepped into Caroline's classroom. I arrived quietly, maybe even timidly, unsure of where to stand, how to move, how to be. I didn't want to disrupt the flow of the space she had so carefully cultivated with her students. I didn't come with a clipboard or a list of questions—I came with a desire to be present, to listen, and to learn. I wanted to be part of

the classroom community, to attune myself to the everyday rhythms of teaching and learning, and to let the questions emerge from there.

But beginnings are rarely easy. I sensed, perhaps rightly, that my presence brought some tension. Caroline, thoughtful and deeply committed to her students, may have wondered whether I had come to evaluate her—to identify what was "working" in her mathematics instruction and what was not. It's a familiar pattern in education research, where teachers are positioned as subjects of study, and researchers as knowers. But that was not the kind of relationship I was seeking. I was not there to extract or to judge, but to encourage and understand how she thought about her mathematics instruction. I wanted to sit with the uncertainties, to be shaped by the textures of her practice, and to learn from the brilliance and wonder of her students.

In those early visits, a certain distance lingered—not mistrust, exactly, but a cautiousness shaped by history. And yet, something began to shift, slowly and quietly. I kept returning. I watched carefully. I listened when students shared ideas, when Caroline offered questions, and when silence filled the room. Over time, the students began to acknowledge me—not as an outsider, but as someone willing to hear them, to laugh with them, to be puzzled alongside them.

Caroline, too, began to let me in—not all at once, but in gestures, in glances, in the way she opened space for me to see what she saw. Our relationship did not follow a tidy arc. It unfolded over time, shaped by pauses and permissions, by shared conversations in the hallway, by invitations to look more closely at what a student had just said or done.

Looking back, I think of this beginning as a kind of dance—one marked by hesitations, shifts, and small steps toward each other. It was not built on a clear plan or methodological certainty. It was built on being present. It was built on Caroline's willingness to teach me—not only about teaching, but about how to be in relation with her and her students.

What emerged from our early interactions was a collaboration rooted not in roles or formal agreements, but in an ongoing process of becoming-with (Haraway, 2016)—of allowing ourselves to be changed by the encounter, by the children's ideas, and by the possibilities that surfaced when we stopped trying to direct the learning and started to follow it.

Caroline

I met Gladys through her role as the university supervisor of my student teacher. When she asked to return the following school year to research in my classroom, I was honored and excited. Having watched her coach my student teacher, I appreciated her calm approach to feedback and her willingness to listen. As a third-year teacher, I was hungry for mentorship, especially in teaching mathematics, and was hopeful that both me and my students would benefit from the partnership.

Gladys's willingness to listen was the best part of the initial months of our collaboration. I had lots of thoughts and feelings about what my students were learning, how they were learning it, and how it could be better. I craved a listening ear to help me reflect on my pedagogical strategies and my students' responses. Gladys let me talk as much as I needed and then asked questions that helped me reflect on my thought process and decision-making. She noticed things my students were doing that I missed in the flurry of teaching. She introduced the possibility that mathematics instruction did not have to be rigid.

Prior to meeting Gladys, my mathematics instructional resource was the mathematics specialist in my building. This specialist believed in my potential as a novice teacher and was quick to welcome me into the school community. She had extensive teaching experience and strong opinions about how mathematics should be taught. In our grade level planning meetings, I witnessed her defend a method for solving word problems that she wanted to implement, building-wide. I saw the reasoning behind her methods and embraced it as the ideal. A single ideal method for teaching fit into my paradigm as a new teacher - I believed there were effective ways of teaching and non-effective ways of teaching. I wanted to learn effective ways in order to meet the needs of my students. I was hyper focused on efficiency.

My conversations with Gladys were a safe space for me to be passionate about teaching and learning. I saw that she too deeply cared about student well-being and student learning. It was this shared passion that helped me receive her reflections and feedback. I remember defending the building-wide strategy for solving word problems to her one day, expressing how this method was necessary for helping students understand the structure of word problems. She responded by asking if students really had to solve problems that way, or if other strategies were possible. I was surprised by the question. It wasn't that I didn't accept or believe other strategies were viable; I had just embraced that this method was the most efficient way for teaching word problem solving. I was too focused on "delivering" the best instruction and lost sight of how my rigidity was limiting the space for diversity in my students' thinking. This conversation was the start of a transformation in how I taught mathematics.

I felt the shift in my relationship with Gladys when she started to use my first name when she talked to me. In my elementary school, all of the adults were on a first-name basis when we were not in front of students. I thrive in a work environment with equal power dynamics. Gladys, in her desire to show respect, continued to use my last name well into the first year we worked together. This made me feel the need to call her Dr. Krause in response. I'm not sure when or how she transitioned to using my first name, but I remember how much more at ease I felt and how much closer I perceived the relationship once we transitioned to first names.

The Classroom

Figure 1

Caroline's classroom

Gladys

The classroom where I spent those early months was small and windowless (Fig. 1). It had the feel of a temporary shelter—walls that held learning in place but left little room for light. Students came and went throughout the day, some staying only a few weeks before transferring to other schools, cities, or even states. It was not unusual to see new faces daily—each arrival quietly asking, in gestures and glances, for orientation in a world that had shifted suddenly and dramatically.

This was a classroom for *newcomers*—a term officially used by many U.S. school districts to describe recently arrived immigrant students, particularly those with "limited English proficiency" and interrupted or "limited formal education" (Krause, 2023). While the designation helps allocate certain resources, I hold tension with such labeling. I use the term here only to acknowledge the institutional frame in which this classroom operated. In practice, I experienced these students not as "newcomers" in a deficit sense, but as young people forging lives, making meaning, and asserting presence in unfamiliar terrain.

The students in Caroline's class were of many ages and from many places: Central America, South America, East Asia, South Asia, and Europe. Some had crossed borders unaccompanied; others had arrived with family members. Some were quiet; others joked and teased with ease. What they shared was a daily encounter with transition—linguistic, cultural, emotional, and spatial.

Within the walls of that small room, Caroline created a kind of refuge. Despite the fluorescent lighting and limited space, there was warmth. Posters in multiple languages. Books with multilingual characters. Handwritten notes and drawings taped to the cabinets. Students helped each other translate tasks, explained the rules of unfamiliar games, and navigated new technologies together. The classroom held more than its physical dimensions—it held a sense of arrival, however temporary, and of learning how to be with others in a new place.

The Mathematics We Learned

Gladys, Caroline, & María Emilia

When I, Gladys, first began visiting the classroom, I intended to listen and to learn—to understand what mathematics meant in that space, for the students and for Caroline. I observed how Caroline organized her teaching around the students' main classwork — assignments and pacing guides provided by the students' general education teachers. She aimed to help students succeed in their other classrooms, often with little information about what scaffolds or background knowledge had been assumed. This meant that Caroline frequently had to interpret, re-teach, and translate—not just between languages, but across cultural, emotional, and procedural gaps.

At the heart of much of this work were arithmetic procedures: multi-digit addition and subtraction, long division, and later, operations with fractions. Many of these procedures appeared without conceptual support or assumed familiarity with number systems and notations

that felt disorienting—even painful—for many of the students and, at times, for me. There were moments when the steps seemed arbitrary, detached from sense-making. But it was precisely in those moments of struggle and dislocation that a small opening emerged: what if these were not *the* procedures, but simply *some* procedures?

From that recognition came a shift. Together, we began experimenting with story problems—narratives that emerged from our lives, not from textbooks. Sometimes these were silly, sometimes deeply personal. For example, one moment that shaped our work emerged during a conversation with a student, Gloria, as we brainstormed ideas for a new math problem. She pointed to a map on the classroom wall and asked, *"Why do the countries and places look so close on the map, but in real life they're really far?"* Her question stayed with me. Gloria—like many immigrant children—had walked and lived the real distances that maps often flatten or obscure. Her observation reframed the conversation we were having and reshaped the instructional decisions that followed. We invented characters and everyday dilemmas that made space for arithmetic: figuring out how to share food, track bus rides, or split chores among family members. We worked with whole numbers and fractions, with drawings and translations, sometimes with manipulatives, sometimes just with our voices. The story problems became both an instructional resource and a window into students' ways of thinking.

One day, while working on addition with 3-digit numbers, I, Gladys, presented a problem to Norma about a collection of feathers. I said that José had a collection of feathers, and, during a walk, he found more feathers. Norma turned her eyes toward me and asked, with genuine curiosity, "Did José pull the feathers off a bird?" For a few seconds, silence stayed with us before we both burst into laughter—a laughter filled with recognition of how differently a problem can be heard or imagined. I had used this same problem many times before in my methods courses with pre-service teachers, and never once had I considered what a child might picture as I told the story. This small but powerful moment revealed the gap between my instructional intentions and the imaginative worlds that children bring into the classroom. What I had imagined as a simple arithmetic context—combining two quantities of feathers—became, in Norma's imagination, a story about an ethical act involving a bird. Her interpretation shifted the frame of the problem entirely, reminding me that story problems are not neutral containers of mathematics; they are invitations into a world that students help co-construct through imagination, language, and experience.

These word problems were more than exercises; they became shared texts through which we made sense of each other's experiences. We recontextualized mathematics through our own stories, reclaiming it as a practice of relational reasoning rather than mere rule-following. As Nasir and Hand (2006) argue, mathematical learning is deeply shaped by the practices and identities of the communities in which it occurs. Here, the mathematics we learned was entangled with our movements, memories, and languages. It was not always clean or easy, but it was honest—and often joyful.

In this experience, the windowless classroom also began to shift. Slowly, we stopped thinking of learning as something that had to stay inside four walls. One afternoon, we stepped outside into the schoolyard—and everything felt different. The sun, the open air, the cracks in the pavement—they all became part of the lesson. We swapped out paper for concrete and pencils for bright sticks of chalk. Math took shape beneath our feet: equations sprawled across the sidewalk, number lines stretched between blades of grass, unknown values solved in the shade of a tree (Fig. 2).

Figure 2

Word problems we solved in the school yard

But we weren't just solving problems. We were sharing bits of our lives. While working through algebraic expressions, someone would pause to recount what they'd cooked over the weekend, or another would chime in with the latest twist in a favorite telenovela. These weren't interruptions—they were part of the rhythm. Our conversations braided together the personal and the mathematical, the mundane and the profound. The yard became a kind of commons, where knowledge wasn't handed down but passed around, shaped by laughter, questions, and shared pauses.

What changed was not just the setting, but our sense of what counted as a classroom, who counted as a learner, and what counted as mathematics. This reorientation was shaped in important ways by María Emilia, an artist whose ways of seeing and working differed markedly from those of the traditional mathematics classroom. Her perspective made room for slowness, for care, for sideways thinking. As her artistic sensibilities met our pedagogical ones, the mathematics began to feel more like us—messy, curious, and full of life.

This shift in how we engaged with mathematics was not the result of a planned intervention. It unfolded slowly, relationally, through the trust that built between us and the students. What began as an effort to "help students catch up" transformed into a space where different ways of knowing could emerge—sometimes unexpectedly, sometimes quietly, but always meaningfully.

These shifts, small as they might seem, point to a larger reimagining of what mathematics education can be. When we moved outside, when we let stories unfold alongside equations, we weren't abandoning rigor—we were expanding its meaning. We were insisting that precision and creativity, structure and spontaneity, could coexist. That understanding mathematics wasn't just about getting answers, but about asking better questions—ones that mattered in our lives.

For me, Caroline, physically stepping outside of the classroom became a way for me to step into new pedagogical knowledge as a teacher. It helped me tune into the individual ways that the students were thinking about mathematics and learned to encourage their thinking instead of funneling them into mine. I found new creativity as I pondered how to use my students' strategies to attain the learning objectives and reconsidered what kind of mathematical knowledge was actually important for them to master. As we lived and breathed mathematics, I found new confidence as a teacher. Through honoring the individuality of my students, I learned to honor my own strengths. It was so freeing.

Too often, mathematics is treated as neutral, sterile, disconnected from culture and emotion (Adams, 2021). But what if we allowed it to breathe? What if we recognized that reasoning lives not just in the mind but also in the body, in relationships, in the textures of everyday life? In our small classroom-turned-yard, we glimpsed what it might look like to teach and learn mathematics in ways that honor the fullness of who students are—their languages, their histories, their humor, and their pain.

This is not a blueprint but a possibility. A reminder that mathematics does not have to be contained. That learning can happen wherever there is curiosity, care, and the courage to reimagine. And that sometimes, to find the missing value, we have to step outside—not just into the yard, but beyond the boundaries of what we've been told learning should look like.

Art as Transformation

Gladys, Caroline, & María Emilia

It was through our collaboration with María Emilia—an artist—that our understanding of mathematics, and especially the children's, began to shift in profound and unexpected ways. María Emilia, a local artist, joined the project not only to co-create with us, but to offer a way of seeing and feeling that extended beyond words and numbers. Her presence brought in the textures, colors, and movements that reconfigured what we had previously considered as mathematical learning.

Rather than us trying to bring art into mathematics, it was María Emilia who invited us to let mathematics breathe through art. Her work was not an add-on or an enrichment—it was a form of knowing. Through her lens, children began to see their mathematical ideas not only as correct or incorrect solutions but as stories, sensations, and images. Concepts that had previously felt difficult to articulate—fractions, operations, shapes, and patterns—gained expressive form through drawings, colors, and murals.

After we shared with María Emilia some of the mathematical concepts and stories we had been exploring together, she helped us reimagine them. The children's word problems and arithmetic routines became visual narratives. Pizzas—once used to represent fractions—transformed into moons dotted with craters (Fig. 3). Numbers written in Pashto[4] became constellations (Fig. 4). Waves of hair traced the ups and downs of our learning (Fig. 5). These visual translations were not merely illustrations but generative interpretations that allowed us to think differently about mathematics and about ourselves as mathematical thinkers.

After that, the math started showing up everywhere in the art, and our strength as a team was in our ability to have conversations that wove together each of our perspectives into a cohesive plan for showing these connections to the students. The rigidity of trying to make math fit into the art dissolved, and each lesson with the students led us to discover new ways of

[4] An official language of Afghanistan.

thinking about these connections. Soon, the color choices, the setting up of chalk lines and grid structures for large-scale painting, and the meaning behind the illustrations all aligned more and more with our goals of making mathematics accessible. And not just accessible—but of creating an awareness of its presence everywhere, making it so visually visceral that we couldn't escape the connection.

This shift in perspective marked a turning point in our collaboration. No longer were we merely planning lessons—we were shaping a shared creative process that gave mathematical ideas physical form and emotional resonance. It was through this evolving dialogue between mathematics, art, and lived experience that the murals took root. The murals became a space where our collective insights materialized, where students could see, touch, and contribute to a mathematical landscape that reflected their own stories and ways of knowing. In the following section, we describe each mural—how it came to be, the ideas and conversations that shaped it, and how it evolved through the students' engagement and imagination. Each mural tells its own story of connection, emergence, and discovery.

Figure 3

A pizza previously used for fraction instruction reimagined as a cratered moon

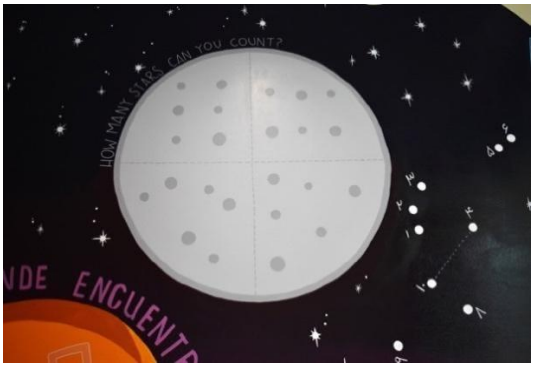


Figure 4

Each dot of a constellation is identified with numbers in Pashto

Figure 5

Hair representing the ups and downs of our learning

The Murals

The murals described in this section are the result of a three-year collaboration between students and us—Caroline, María Emilia, and Gladys. Each summer, we returned to paint together, but the ideas that shaped the murals were not born in a single season. They grew slowly, through months of classroom conversations, sketches, and small discoveries that accumulated over time. This continuity allowed us to know one another beyond the boundaries of roles—teacher, artist, researcher, student—and to reimagine mathematics as something that could live in color, in gesture, in the rhythm of shared work. Each mural holds traces of this process: moments of trust, laughter, frustration, and insight that became part of our collective making.

At first, we imagined painting the murals inside the local elementary school. It made sense at the time—or so we thought. But soon it became clear that for the families, transportation to the school would be a burden, not a bridge. In less than a week, and with the support of the dean of the School of Education, we rearranged everything. The murals would be painted in the university building, more centrally located to where the families lived. Caroline's deep relationships with the families—nurtured through years of teaching and care—were instrumental in making this change possible. Her trust became our bridge. The shift in place, which at first felt like a logistical adjustment, transformed the project. We began walking together from the families' homes to the university, sharing food, stories, and unhurried time. Those walks became a quiet ritual, a way of arriving together into the work.

Over the three years, our collaboration became more fluid and unpredictable—alive in the way that real relationships are. Decisions were shared, ideas layered and reworked, and boundaries between teaching, art, and research blurred. We sought to create spaces where students could see themselves and their communities reflected in mathematics, and where painting could be a way of thinking mathematically. What follows is not just a description of murals, but an unfolding of relationships—how art, mathematics, and trust came to inhabit the same space.

Figure 6

Students working on first mural

Figure 7

First mural: How Many Stars Can You Count?

How Many Stars Can You Count?

This is the first mural of the three (Fig. 6 and Fig. 7). The artwork reflects mathematical concepts the students explored throughout the 2021–2022 school year at their elementary school. The theme of the mural originated from a student's creative solution to a fraction problem, where a pizza was used to represent quarters. Inspired by this, María Emilia re-envisioned the pizza as the moon (Fig. 3), sparking the idea to incorporate constellations (Fig. 4), which inspired the title. The dots of the constellations can be connected following the numbers written in Pashto, emphasizing the multilingual and multicultural richness of the project. As the first in a series of

three murals, this project marked the beginning of our journey of learning to collaborate and meld our ideas effectively. Reflecting on this initial effort, the three of us provided significant guidance and support to the students, helping them both to navigate the creative, artistic, and measurement processes involved in mural making and to build their confidence — a foundation that set the stage for their deeper involvement in the design and development of the subsequent murals.

This mural also introduced the students to the concept of color theory, which became central to the development of the other two murals. Exploring how to mix primary colors to obtain a variety of hues and shades not only enriched the artistic process but also inspired meaningful connections to mathematical concepts (Krause et al., 2024), laying the groundwork for the integration of mathematics and art in the subsequent murals.

Figure 8

Researcher and artist working on the second mural

Figure 9

Details of second mural

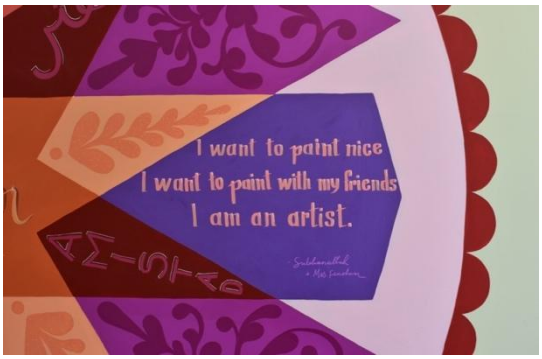


Figure 10

Second Mural: Tessellations of Thought: Drafting, Revising, Creating

Tessellations of Thought: Drafting, Revising, Creating

This is the second mural (Figs. 8, 9, and 10) in the series of three murals. This mural draws inspiration from the intricate beauty of tessellations used in traditional Islamic architecture and the richness of writing and speaking in different languages. We interwove these concepts with aspects of the history of the region and elements of poetic composition. Central to its design is a representation of the process of revising and refining ideas, depicted through a sequence of images: a Draft, a Revised Draft, and a Final Product.

Building on the experience gained from the first mural, this project became a more ambitious endeavor, requiring two weeks of intensive work to complete. With a strong collaborative foundation, the three of us shifted focus to empowering students, giving them greater responsibility in the creative and developmental process. Students designed their own giant compasses to trace angles and circles, and they collaborated in creating the grid that served as the mural's foundation. Additionally, students designed their own poetry, which combined their experiences creating the mural and their interdisciplinary learning. This mural stands as a testament to the evolving collaboration among the three of us and the growing confidence and skills of the students, who took an active role in shaping the final product.

Figure 11

Sketches of Mural 3 drawn on the wall and the process of our work creating the mural

Figure 12

Third mural: What Is in a Recipe?

What is in a Recipe?

This is the third and final mural (Figs. 11 and 12). This mural celebrates the rich cultural traditions and flavors of home through the lens of family recipes while drawing meaningful connections to mathematics. Working closely with the families of the participating students, we explored favorite dishes, spices, and cooking traditions that bring people together. These shared experiences informed the design, infusing the artwork with a deeply personal and communal essence. Mathematics was woven into the project as students developed their own “recipes” for creating paint colors. They created their own units of measurement, such as "mega drops," to mix precise hues, demonstrating creativity and problem-solving. These mathematical processes mirrored the careful measurements and proportions found in cooking, reinforcing the parallels between recipes for food and the recipes they created for art.

In this final mural, students took the lead, driving the design process and selecting the color palette. Open spaces within the mural intentionally reveal its creative evolution — from the initial grid and sketches to the final layers of paint — highlighting the students’ journey and growth as creators. This mural stands as a celebration of collaboration, creativity, mathematics, and the rich tapestry of cultural traditions that connect us all.

As the final mural came together, it marked not only a culmination of the students’ work but also a turning point in our own development as educators. The collaborative process—shaped by student leadership, family engagement, and the integration of cultural knowledge—pushed us to reconsider the roles we typically assume in the classroom. Rather than guiding from the front, we found ourselves learning alongside the students, responding to their ideas, and adjusting our plans in real time. The creative risks we took, and the shared authorship that emerged, opened up new ways of thinking about teaching, learning, and knowledge-making. In the following section, we reflect on how these experiences transformed our identities as educators and reshaped our pedagogical commitments.

Who We Are (Our Transformation)

Gladys

My training in mathematics education gave me tools to trace the contours of teacher knowledge and children's mathematical thinking. Early on, I studied how teachers anticipated students' fraction strategies and how carefully chosen numbers could open or foreclose mathematical possibilities. These inquiries were structured, tidy—even elegant in their simplicity. And yet, as I deepened this work, especially through NSF-funded projects, I became increasingly aware of its limits. My analyses often stopped short of the lived complexities of multilingual classrooms, the ambivalence of teacher decision-making, and the messiness of real learning encounters.

I began to question the boundaries of what counted as "rigorous" research. I saw how the desire for clear evidence and causal claims could crowd out other kinds of knowing—bodily, intuitive, linguistic, relational. This shift was not abstract. It came from being with teachers and bilingual families, from witnessing how mathematical meaning is made in movement, in gesture, in mistranslation, in silence. It came from listening to pre-service teachers struggle—not only with the content of mathematics but with the emotional labor of navigating schools that did not always value the languages they spoke or the identities they carried.

Over time, I have come to think of myself not as someone who produces knowledge about teachers and children but as someone accountable to them. My work now asks different questions: What forms of knowing are obscured when we prize generalizability over specificity? What becomes possible when we center the unpredictability of classrooms, the opacity of others, and the ethics of co-presence?

This project invited me to lean into those questions. With Caroline and María Emilia, I learned to see research as a form of accompaniment. Our collaboration was not about scaling or transferring practices across borders, but about honoring the specificity of each context—each classroom, each child, each teacher. We did not begin with answers. We began with a commitment to staying with the trouble, to resisting the urge to resolve tension too quickly, and to making space for the multiplicity that multilingual and multicultural pedagogies demand.

Caroline

My tendency towards effectiveness and efficiency, shaped by fast-paced American culture and an achievement-oriented K-16 educational experience, led me down a path as a teacher that caused me to value my students' individualities in name rather than practice. I entered the profession excited to teach immigrant multilingual students because of all that I could learn from them. I wanted to learn their languages, honor their cultures, and be a safe person for them as they navigated their new schools. While I lived true to that desire in the non-academic moments of the day (walking the students to and from class, arrival and dismissal, and in the lunchroom), I was distracted from that lens as soon as there were learning objectives in front of me. Through working with Gladys and María Emilia, I learned that efficiency does not necessarily lead to more or better learning. Instead, letting go of the time pressure and being present in the moment with my students led to learning experiences that were sticky for them. Similar to Gladys, I needed to let go of the simple and the tidy and embrace the messiness that is teaching and learning in real classrooms.

María Emilia 

When I came into this project, I didn't realize the impact it would have on my understanding of my own art practice. Not only that, but it also really made me think about the missed opportunities that exist to learn and merge knowledge across disciplines. Our first mural, which focused on where in our everyday world we could find mathematics, truly made me think about the amount of math I use in my own creative practice. Calculating scale and proportions and quantities seemed second nature to me, and until I began to collaborate with Gladys and Caroline, the connection of using this "second nature knowledge" to teach mathematical concepts wasn't evident right away. The more conversations we had about how to connect mural making with mathematics, the more apparent and seamless those connections became. The evidence was there the whole time, and I just had to look through a different lens, a lens that both Caroline and Gladys led me toward, to make this information accessible to the students.

Mixing colors, which was something so instinctual and almost mechanical to my brain, became an exercise in awareness of my art practice. This awareness led me to be more present in the moments when students pointed out gradients in color, hues, and tints, and with cues from Gladys and Caroline, we were able to bridge the mechanical practice of art making into an intellectual understanding of ideas and concepts in the world of mathematics. By the third year, the culmination of the students mixing and color matching their own colors (not a simple exercise even for college students in an art classroom), and being able to create their own paint recipes, was such a sense of accomplishment for me in the fact that it was the ultimate exercise where math and art collided.

With this collaboration, the students and ourselves were able to step outside the limits of an 8"x11" sheet of paper, where a mundane word problem and a few color pencils and markers might have constricted us, and we were able to expand our canvas and our understanding of math. We now use our living world, our languages, our food, and our culture to mix hundreds of different colors, all on our own, and to literally paint outside the box (of crayons) and math.

In the End … Mathematics is a Collective Practice

Gladys, Caroline, & María Emilia 

As the project came to a close, what remained was not just a mural on a wall or lessons in a notebook, but a living archive of our collective becoming. The mathematics, the stories, the colors, and gestures—they now belong to the community. These murals carry the weight of our questions and the warmth of our laughter, but they also stretch beyond us. They speak in voices that are not ours alone. Each word problem invented, each chalk drawing on the sidewalk, each multilingual conversation in the yard—these were not isolated events but part of a larger narrative about what mathematics can be when rooted in the lived experiences of children, families, and teachers.

This work was never just about what students were learning—it was also about how we, as educators and researchers, were being transformed. My training in mathematics education gave me tools to trace the contours of teacher knowledge and student thinking. But as I moved deeper into bilingual classrooms, those tools felt increasingly insufficient. What of the gestures, the silences, the mistranslations? What of the emotions carried into classrooms where the fullness of students' identities was not always welcomed? I began to see that the pursuit of tidy claims and clean coding schemes often left little room for the messiness of learning as it unfolds in real time, in real lives.

It was in this tension that new questions began to take shape—questions that demanded a different kind of listening. What becomes visible when we stay with the uncertainty? What becomes possible when we shift from extracting findings to accompanying communities? This project gave form to those questions. With Caroline and María Emilia, I learned to see research not as a method of control or measurement, but as an act of presence and relational care. We did not set out to scale practices or generalize across contexts. We committed instead to honoring the specificity of each mural, each conversation, and each student's insight.

María Emilia's reflection, for instance, reminds us that knowledge often hides in the everyday until we shift the lens. The intuitive, bodily practices of mixing color and estimating proportions in her art became a new terrain for mathematical exploration—not because we imposed mathematics on art, but because we were finally listening differently. As she shared, these insights did not emerge in isolation; they were co-constructed through conversations, careful noticing, and the joy of watching students create their own paint recipes, fusing disciplines with creativity and precision. This is the kind of learning that exceeds the page—it breathes, it stains fingers, it lingers in the air long after class has ended.

Caroline's presence, too, was one of accompaniment and humility. She did not come to impose knowledge, but to hold space—for uncertainty, for language, for the quiet thinking that often gets overlooked. Together, as María Emila described above, we stepped outside the limits of the 8x11 paper and invited students into a practice of expansive sense-making. Their mathematics no longer sat still; it moved across languages, between bodies, and onto walls.

Through all this, we came to understand that classrooms are not bounded by walls, and that learning can live in sidewalk chalk, in a shared bowl of food, or in a reimagined map that refuses the logic of borders. Students like Gloria were not simply learning math—they were theorizing their world. And we, in turn, were learning to recognize those moments for what they were: acts of intellectual and political agency.

In the end, our most important learning was about letting go. The murals no longer belong to us. The questions we asked and the relationships we built have expanded, taken up, and transformed by others. What we leave behind is not a model to be replicated, but an offering—a practice of listening and noticing, of staying with the trouble, of honoring the multiplicity that multilingual and multicultural pedagogies demand. We learned to teach differently. We learned to research differently. And most of all, we learned to trust that knowledge made in community will always exceed our intentions. It will continue to grow—unfolding across walls, languages, and generations.

A Proposal Beyond the 8x11 Page

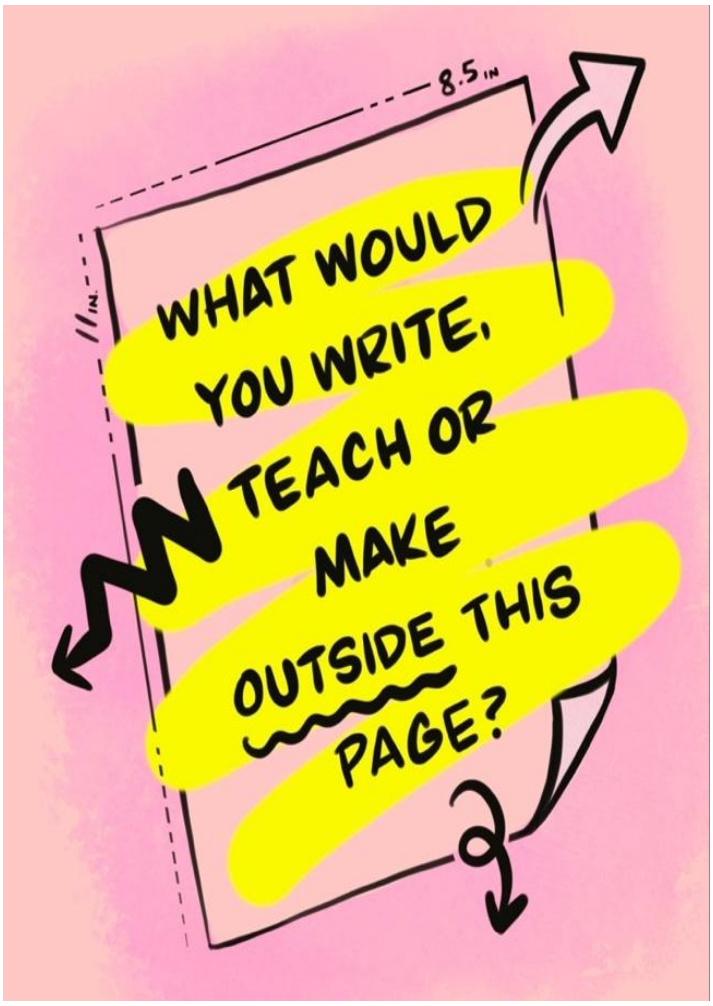
As we close these reflections, we offer you not a conclusion, but an opening. A question. What would you write, teach, or make outside the 8x11 page? (Fig. 13) What might emerge if we allowed classrooms to spill into courtyards, if equations found space on sidewalks, and if

meaning-making welcomed silence, gesture, mistranslation, and joy? We propose this not as a metaphor, but as a material invitation: to look beyond the tidy boxes of standardized pedagogy and to design learning with your full senses, in companionship with your students and communities.

This project taught us that mathematics does not reside only in worksheets or assessments—it lives in recipes passed down in kitchens, in the ratios of paint mixed by hand, in the cadence of a story told in more than one language. We have seen how a windowless classroom can breathe when students are allowed to bring their lives into the lesson, when mural walls become pages, and when questions grow from shared experience rather than imposed templates. To our fellow educators and researchers: what might your practice become if you shifted the frame? What forms of knowing might you honor, what relationships might you cultivate, and what learning spaces might you reimagine? In stepping outside the page, we do not lose structure—we create new ones. Rooted in trust. Alive with color. Shared with others. Let this be your invitation to paint, to listen, to wonder, to teach outside the lines.

Figure 13

A proposal for the reader



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