



Cross Cultural Perspectives on Rigor and Flexibility in United States Higher Mathematics Education

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Abstract:

This article presents a critical reflection on the cross-cultural challenges of transitioning from a classical mathematics education system to a contemporary U.S. higher education context. Drawing on autoethnographic experiences and scholarly literature, it identifies a false dichotomy between the procedural rigor of classical models and the conceptual flexibility of inquiry-based learning (IBL). In response, the article introduces the original framework of "pedagogical bilingualism", the capacity to fluidly integrate teaching practices from both traditions. This is operationalized through the Structured Inquiry Model, a three-layer framework (Structured Core, Interactive Engagement, Exploratory Application) designed to simultaneously build procedural fluency and conceptual understanding. Practical case studies from calculus and algebra demonstrate the model's efficacy in addressing diverse student preparation, reducing mathematics anxiety, and fostering deep engagement without sacrificing rigor. The article concludes with implications for supporting internationally trained faculty and redesigning professional development to foster this hybrid approach, arguing that the future of mathematics education lies in a conscious synthesis of global strengths rather than a choice between them.

Keywords: Mathematics Education; Higher Education; Inquiry-based Learning (IBL); Pedagogical Bilingualism; Cross-Cultural Pedagogy; Structured Inquiry Model

1. Introduction

Growing up, I never questioned the way mathematics was taught. The classroom I knew was orderly, disciplined, and built on a clear hierarchy: the teacher explained, the students listened, and learning happened through repetition and persistence. In this classical system, mathematics was a training of the mind. Hours of problem-solving, structured lessons, and the expectation of precision shaped my academic identity. I learned to value rigor and trust that if I followed the procedures long enough, understanding would come. This model felt universal.

It was only when I entered the U.S. higher education system as an instructor that I realized how deeply my own formation had shaped my assumptions. The quiet, structured classrooms of my memory were replaced by an environment demanding flexibility, communication, and adaptation. My students arrived with profoundly different relationships with mathematics, some with conceptual intuition but shaky skills, others with anxiety or a history of discouragement.

They expected interactive discussions and to participate in constructing their understanding.

This transition was not merely professional; it was personal. I found myself negotiating between two identities: the student I once was and the teacher I was becoming. I was pulled between the comfort of classical rigor and the need to meet students where they were. I came to see that mathematics education is deeply culturally embedded, and that teaching across these systems requires a kind of pedagogical bilingualism.

My personal journey mirrors a profound, global paradigm shift. From the demanding regimes in East Asia, where South Korean students, for instance, average 10.4 weekly hours on mathematics, to more varied Western approaches, the intensity of math education varies widely. Yet, a universal reevaluation is underway. Driven by concerns over engagement and conceptual understanding, contemporary approaches like Inquiry-Based Learning (IBL) are challenging the long-standing tradition of authoritative knowledge transmission.

This article is a reflection on that journey from classical rigor to contemporary flexibility. It explores the tensions and lessons of navigating this divide, arguing that the core challenge is not a binary choice but a necessary synthesis. Drawing on my experiences and scholarly research, I will examine the promise of inquiry-based methods, the empirical evidence for their efficacy, and the path toward a holistic future for U.S. higher mathematics education, one that bridges two worlds to build a pedagogy that is both rigorously demanding and authentically engaging.

2. Literature Background

Mathematics education is not a monolithic endeavor but a reflection of deeply embedded cultural and pedagogical values, a fact consistently highlighted by international assessments. The OECD's PISA studies routinely show students from East Asian countries like China, South Korea, and Singapore outperforming their global peers in mathematical literacy. This success is often attributed to cultural emphases on effort, intensive practice, and highly structured, disciplined curricula, hallmarks of the classical system that produce exceptional procedural fluency and symbolic mastery (Khalaf & Zin, 2018). This model, built on rigorous teacher-led instruction, stands in stark contrast to the pedagogical evolution that has characterized U.S. mathematics education over recent decades.

In the United States, a significant reform movement has championed a shift from passive reception to active construction of knowledge. This is epitomized by the rise of Inquiry-Based Learning (IBL), an umbrella term for pedagogies that engage students in mathematical exploration, problem-solving, and conjecture (Dreyøe et al., 2012). A substantial body of literature advocates for this approach, with meta-analyses in STEM education broadly confirming that active learning boosts performance and reduces failure rates. Specific to mathematics, studies such as Khasawneh et al. (2023) demonstrate that IBL can lead to higher achievement in courses like college algebra compared to traditional lecture-based learning. Proponents argue that IBL deepens conceptual understanding and fosters a more positive disposition toward the subject (Gómez-Chacón, 2024).

However, the empirical picture is nuanced. While some studies, including a recent analysis by Liu et al. (2024), affirm that inquiry-

based pedagogy can improve math performance, critical voices like Evans & Dietrich (2022) caution that a blanket call for reform in tertiary mathematics may be unjustified, underscoring that effectiveness is highly dependent on context and implementation. This debate highlights that the transition is not a simple substitution of methods but a complex cultural shift.

This shift brings the affective dimensions of learning to the forefront. In the diverse U.S. context, where student preparation and mathematical backgrounds vary dramatically, instructors must attend not only to content but also to confidence, motivation, and identity. Research indicates that IBL can positively influence students' attitudes and reduce anxiety by valuing process over mere product (Gómez-Chacón, 2024). Yet, this requires faculty to be adept at facilitating such environments, a skill that often requires targeted professional development (Fry et al., 2025).

Consequently, a growing strand of literature examines the challenges faced by internationally trained instructors who must navigate this pedagogical transition. These educators often engage in a form of "pedagogical code-switching" or, as this paper terms it, pedagogical bilingualism, moving between the teaching culture of their own training and the student-centered expectations of their U.S. institutions. This process involves not only adopting new methods but also re-examining deeply held beliefs about authority, rigor, and how understanding is demonstrated, a theme explored in global comparative studies (Repuya, Trazona, & Acio, 2025).

This literature background frames my personal experience within a broader scholarly conversation. It positions faculty like myself, trained in classical systems, at the intersection of global pedagogical debates. The following sections will draw upon this context to explore the tangible tensions and lessons of integrating the demonstrated strengths of classical rigor with the compelling, if complex, promise of contemporary, inquiry-driven flexibility.

3. Classical Mathematics Education: The Strengths and Limitations of My Formation

My academic identity was forged in the crucible of classical mathematics education, a system prevalent in East Asia and North Africa. This model is built on an unwavering commitment to rigor, discipline, and procedural mastery. The classroom was a hierarchical space where the teacher was the authoritative source of knowledge, and learning was achieved through careful imitation, sustained practice, and repetition. This environment, while often perceived as rigid from the outside, was designed to build a formidable foundation in logic and symbolic manipulation.

A defining feature was teacher-centered instruction. The teacher's explanation was the definitive source of truth, and students were expected to listen attentively and reproduce demonstrated methods with precision. I recall moments from my own schooling when asking for clarification could be perceived as challenging authority. Much of our learning occurred in silence, through the meticulous replication of examples written on the board. This culture fostered a deep respect for the discipline but often discouraged questioning and intellectual risk-taking.

The system's greatest strength lies in the deep procedural fluency it cultivates. Students complete extensive, repetitive exercises and timed drills, building not just familiarity with techniques but also what can be termed "logical stamina", the ability to persist through long, complex symbolic manipulations. This intensive practice,

embedded in a stable and uniform curriculum, ensures that students develop a high level of skill and automaticity with core algorithms. The perseverance I built through years of rigorous problem sets became an invaluable asset in my own mathematical journey.

However, the limitations of this approach are significant. The intense focus on correctness and efficiency often comes at the expense of student agency and conceptual understanding. Because the process is highly structured and questioning is discouraged, students may excel at executing procedures without grasping the underlying principles. I mastered lengthy algebraic manipulations without truly understanding why they worked, trusting that comprehension would eventually emerge from practice. Furthermore, the high-stakes, correctness-oriented environment can foster anxiety and a fixed mindset, where the fear of public error suppresses the very curiosity mathematics should ignite.

In sum, my classical formation endowed me with technical prowess and intellectual discipline, but it also presented a narrow view of mathematical success, one that prized compliance and procedural accuracy over creative exploration. This background set the stage for a profound personal and pedagogical reckoning upon entering the U.S. higher education landscape.

4. The Cross-Cultural Classroom: Challenges in U.S. Higher Education

Transitioning from a student in a classical system to an instructor in the U.S. higher education system brought a set of pedagogical and cultural challenges that forced me to re-evaluate my deepest assumptions about teaching and learning. The American mathematics classroom, shaped by values of interaction, inclusivity, and student-centered learning, presented a stark contrast to the disciplined silence of my past.

One of the most immediate challenges was the diversity in student preparation. Unlike the relatively uniform starting point created by national curricula in classical systems, my U.S. classrooms contained students with wildly varying levels of algebraic fluency, prior exposure to advanced topics, and comfort with abstract reasoning. In a single course, I encountered students who had completed calculus in high school alongside those for whom college algebra was a significant hurdle. This heterogeneity necessitated a move away from one-size-fits-all instruction toward differentiated support and multiple entry points into problems, a skill my prior training had not equipped me with.

Equally salient was the central role of student affect and mathematical identity. Many students approached mathematics with pronounced anxiety, self-identifying as "not a math person"—a concept foreign to the effort-oriented ethos of my upbringing. In the U.S. context, teaching content was inextricably linked with addressing students' beliefs, motivations, and fears. I quickly learned that building mathematical competence required simultaneously building mathematical confidence.

Pedagogically, I was expected to shift from a "sage on the stage" to a "guide on the side." This meant facilitating group discussions, designing exploratory activities, and valuing the process of inquiry as much as the final answer. Initially, this felt uncomfortable;

relinquishing control and allowing for ambiguous, struggle-filled moments seemed at odds with the efficient transmission of knowledge I valued. I also observed a unique tension: while American students were often more verbally engaged and conceptually curious, many struggled with the "symbolic stamina" that my classical education had so effectively built. They could discuss ideas but faltered on sustained computation.

This transition was, therefore, not merely professional but deeply personal. I was navigating between two teaching identities and two educational cultures. This cross-cultural challenge highlighted the need for a new pedagogical approach—one that could honor the strengths of my classical training while effectively meeting the needs of my diverse, dynamic U.S. classrooms. This need catalyzed the development of the hybrid model discussed in the following section.

5. Bridging the Divide: The Structured Inquiry Model and Pedagogical Bilingualism

The challenges described in the previous section are not merely personal; they are manifestations of a fundamental tension in mathematics education. The scholarly debate often presents a binary choice between classical rigor and contemporary flexibility, with proponents of IBL citing improved performance and engagement (Khasawneh et al., 2023; Liu et al., 2024) and skeptics cautioning against a blanket reform (Evans & Dietrich, 2022). My experiences in both systems have led me to a different conclusion: the most effective pedagogy is not a single, pure method, but a strategic synthesis. This synthesis is embodied in a practice I term pedagogical bilingualism and operationalized through the Structured Inquiry Model.

5.1. Defining Pedagogical Bilingualism

Pedagogical bilingualism is the capacity of an educator to fluidly navigate and integrate teaching practices from different educational cultures. It moves beyond the simple "blending" of methods to represent a conscious, context-sensitive approach where the instructor selects the right pedagogical tool for the specific learning objective. A pedagogically bilingual instructor can deliver a clear, direct explanation to build procedural fluency with the same intentionality they employ when facilitating an open-ended, exploratory task to foster conceptual understanding. This approach directly addresses the critiques of pure traditionalism and the implementation challenges of pure IBL, creating a more balanced, adaptable, and effective pedagogy.

5.2. The Structured Inquiry Model: A Framework for Integration

To translate the theory of pedagogical bilingualism into a practical framework, I developed the Structured Inquiry Model for Higher Mathematics. This model formalizes the blend of strategies I cultivated to meet the needs of my diverse U.S. classrooms. It consists of three interconnected layers, designed to develop both rigorous skill and intellectual curiosity. The model's architecture, depicted in Figure 1, consists of three interconnected layers.

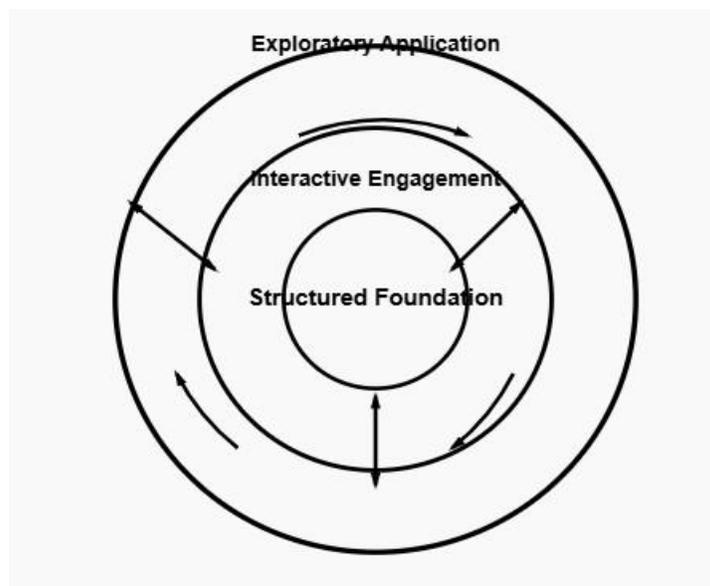


Figure 1: Learning framework represented by three concentric structural layers. Arrows indicate fluid, bidirectional movement and cross-layer interaction between foundational structure, active engagement, and exploratory application.

- **The Structured Core:** This foundational layer ensures procedural fluency and logical stamina. It includes weekly problem sets focused on core skills, brief "fluency drills," and clear, direct instruction for new algorithms. This is the non-negotiable backbone of rigor, providing the stability and discipline essential for advanced work.

- **The Interactive Layer:** Wrapped around the core, this layer fosters conceptual understanding and communication. Here, we employ think-pair-share activities, peer instruction, and Socratic questioning. This is where students debate why a method works, connect different representations, and articulate their reasoning, addressing the U.S. imperative for active learning.

- **The Exploratory Layer:** The outermost layer connects mathematics to the wider world, fostering creativity and application. This involves short projects, analysis of real-world datasets, and experimentation with tools like Python or Desmos. This layer answers the student question, "When will I ever use this?" and fulfills the goal of developing flexible, applied problem-solvers.

The model is dynamic; students and instructors fluidly move between these layers within a single unit or even a single class session.

5.3. Principles for a Bilingual Classroom

Implementing this model is guided by several key principles:

- **Use IBL to Launch Concepts;** Use Direct Instruction to Consolidate Them: Begin a new topic with an exploratory problem that sparks curiosity and reveals the "why" (Dreyøe et al., 2012). For example, before stating the Quadratic Formula, students can investigate patterns in solving specific equations. Once the need for a general method is established, a clear, direct explanation provides the necessary structure and efficiency.

- **Build "Symbolic Stamina"** through Deliberate Practice: The bilingual classroom intentionally incorporates short, focused sessions of deliberate practice, framed not as rote work, but as essential "cognitive training." This builds the logical stamina that enables students to engage in complex inquiry without being

bogged down by computational uncertainty.

- **Foster a "Growth Mindset" through Rigor and Support:** The model reframes difficult problems not as threats, but as opportunities for growth, directly addressing math anxiety (Gómez-Chacón, 2024). The instructor provides a supportive environment where struggle is expected but strategically intervenes with classical-style guidance to prevent frustration.

- **Value Both Product and Process in Assessment:** Moving beyond high-stakes exams, the bilingual model employs a hybrid assessment strategy. It includes traditional tests to ensure procedural mastery but also incorporates projects, verbal explanations, and self-reflections that reward the process of inquiry and growth.

This model provides a practical framework for navigating the cross-cultural challenges of modern mathematics education, creating a classroom that is both rigorously demanding and inclusively engaging. The following case studies illustrate its application in action.

6. Case Studies: The Model in Action

The true test of the Structured Inquiry Model lies in its application within the dynamic environment of the classroom. The following case studies, drawn from my own teaching practice, illustrate how this hybrid approach and the principle of pedagogical bilingualism directly address core challenges in U.S. higher mathematics education. Each case demonstrates the fluid movement between the model's three layers, Structured Foundation, Interactive Engagement, and Exploratory Application to achieve specific learning outcomes.

Case Study 1: Transforming Procedural Practice into Conceptual Inquiry (Calculus)

The Challenge: In a classical approach, the derivative is often taught as a mechanical procedure for calculating slope. Students learn how to compute it but frequently lack a sense of why it is a

foundational and revolutionary concept, leading to fragile, superficial knowledge.

The Structured Inquiry Approach: A standard problem on computing derivatives was redesigned into a multi-layered task that mirrors the model's layers:

- o **Exploratory Application (The Hook):** Students were first given graphs of position versus time for two different vehicles and asked, "Which vehicle is moving faster at time $t = 3$?" and "How can you be sure?" This contextual problem forced them to grapple with the concept of instantaneous rate of change without any formal tools.

- o **Interactive Engagement (The Discussion):** In small groups, students debated their reasoning, proposing ideas like using average speed over smaller intervals or drawing tangent lines. This discussion naturally converged on the need for a precise, general method, creating a genuine "need to know."

- o **Structured Foundation (The Tool):** I then provided direct, clear instruction on the limit definition of the derivative as the formal tool that answers their question. This was followed by targeted, structured practice on the computational algorithm, which students now approached with a clear purpose.

The Outcome: This sequence, moving from exploration to structure, resulted in students who could not only compute derivatives accurately but also explain their meaning graphically and contextually. The model successfully built both procedural fluency and deep conceptual understanding, with the structured practice being motivated by the exploratory and interactive phases.

Case Study 2: Bridging the Preparation Gap with Tiered Structure (College Algebra)

The Challenge: The wide variance in student algebraic fluency, a hallmark of the U.S. context, makes one-size-fits-all instruction ineffective, often boring advanced students and overwhelming others.

The Structured Inquiry Approach: I implemented a tiered system rooted in the model's layers to create an inclusive yet rigorous learning path:

- o **Structured Foundation (Differentiated Core):** A diagnostic quiz identified skill gaps. Students were then assigned one of two parallel practice sets for core skills: "Foundational" (heavily scaffolded) and "Fluency" (more complex applications). This ensured every student was working at an appropriate level to build essential procedural mastery.

- o **Interactive Engagement (Unifying Discussion):** Crucially, despite different practice sets, the whole class reconvened for the same interactive activity, such as a group problem that required the core skill. This ensured a common conceptual experience, prevented tracking, and allowed peers to learn from each other's diverse approaches.

- o **Exploratory Application (Shared Challenge):** All students engaged with the same "low-floor, high-ceiling" exploratory task. For example, a problem on exponential functions could be approached by some students with a table of values (low floor) while others derived a general formula (high ceiling). This ensured everyone could access the problem while being appropriately challenged.

The Outcome: This approach maintained high expectations and rigor for all while providing the necessary, differentiated scaffolding. It effectively managed classroom diversity without sacrificing coherence, ensuring no student was left behind and all

remained engaged.

Case Study 3: Cultivating Resilience to Reduce Mathematics Anxiety

The Challenge: The fear of failure, often heightened in high-stakes, correctness-oriented classical environments, can paralyze students and prevent them from engaging with challenging problems.

The Structured Inquiry Approach: I explicitly worked to build a "culture of productive struggle" by strategically blending affective and cognitive support across the model's layers:

- o **Structured Foundation (Safety through Predictability):** Clear rubrics and consistent weekly routines provided a sense of safety and predictability, reducing the anxiety of the unknown. Students knew what to expect and how they would be assessed.

- o **Interactive Engagement (Normalizing Struggle):** Think-Pair-Share activities were used specifically for the most difficult problems. Hearing peers articulate their confusion and collaboratively work through ideas normalized struggle, transforming it from a solitary failure into a shared, collaborative process.

- o **Growth-Mindset Feedback:** Formal and informal feedback was reoriented from "right/wrong" to praising effort, specific strategies, and improvement. I shared my own problem-solving struggles to model persistence and demonstrate that expertise is built through effort.

The Outcome: Students demonstrated a marked increase in their willingness to attempt challenging problems and participated more freely in class discussions. The classroom culture shifted from a place to prove one's ability to a place to grow one's ability.

Together, these cases demonstrate that the tensions between classical rigor and contemporary flexibility are not merely theoretical but are actionable instructional challenges. The Structured Inquiry Model, enacted through pedagogical bilingualism, provides a practical framework for making deliberate, strategic choices. By consciously selecting and integrating methods from a diverse pedagogical repertoire, educators can create a mathematics education that is truly rigorous, inclusive, and empowering, preparing students not just to pass exams, but to think like mathematicians.

7. Discussion: Implications and Recommendations for a Hybrid Future

The case studies demonstrate that the Structured Inquiry Model is not merely a theoretical construct but a viable and effective framework for addressing persistent challenges in mathematics education. However, the implications of this work and the broader practice of pedagogical bilingualism extend far beyond individual classroom strategies, carrying significant weight for faculty development, institutional policy, and the global pedagogical landscape.

7.1. Implications for Faculty and Institutions

The move toward a hybridized pedagogy necessitates a shift in how we prepare and support educators, particularly in an increasingly globalized academic world.

This synthesis has particular significance for internationally-trained faculty. The framework of pedagogical bilingualism offers

an empowering new identity. Educators from classical systems should be recognized not as outsiders needing to fully assimilate, but as vital contributors who bring indispensable strengths in rigor, deep content knowledge, and structured curriculum design. The goal becomes not replacement, but expansion, leveraging their inherent strengths while acquiring and integrating the facilitative tools of student-centered pedagogy. This reframing can alleviate the sense of cultural dissonance and transform it into a professional asset.

For U.S. Institutions and Faculty Development: To realize the benefits of this synthesis, institutions must move beyond simply mandating "active learning." Support must be provided through professional development that, as highlighted by Fry et al. (2025), is itself hybrid in nature. This includes:

- o **Critical Reflection:** Creating spaces for instructors to analyze their own educational formation and its deeply held biases about authority, rigor, and the nature of understanding.

- o **Mentoring and Coaching:** Providing sustained, practical support from peers and mentors as faculty experiment with blending methods, moving beyond one-off workshops on "how to do IBL."

- o **Course Design Collaboration:** Incentivizing and providing time for faculty to work in teams to design curricula that thoughtfully sequence direct instruction, interactive engagement, and exploratory tasks.

For a Global Context: This model aligns with a growing recognition that no single pedagogical tradition is sufficient to prepare students for the complex, data-driven challenges of the future. The integration of structure and inquiry is a universal principle for cultivating versatile, resilient, and adaptable mathematical thinkers. It provides a common framework for productive dialogue between different educational cultures, moving the global conversation beyond simplistic comparisons and toward meaningful synthesis.

7.2. Acknowledging Challenges and Future Directions

While the promise of this hybrid model is compelling, its implementation is not without challenges. Acknowledging these is essential for realistic and sustainable adoption.

- **Practical Constraints:** Implementing this model demands more from instructors in terms of planning, resource development, and in-class flexibility. It requires careful management of time and institutional constraints, such as standardized curricula and large class sizes that can incentivize a return to traditional lecture formats.

- **Assessment Alignment:** A hybrid pedagogy requires hybrid assessment. Developing and grading a mix of traditional exams (to ensure procedural mastery) and open-ended projects or process-oriented assignments (to measure conceptual understanding and growth) is more time-consuming and complex.

- **Areas for Future Research:** This work opens several avenues for further investigation. Future studies could quantitatively measure the impact of the Structured Inquiry Model on both procedural fluency and conceptual gains compared to either pure approach. Research is also needed on the most effective professional development models for fostering pedagogical bilingualism, especially for faculty experiencing significant cross-cultural teaching transitions. Finally, longitudinal studies could track whether such a hybrid approach improves long-term retention and persistence in STEM fields.

In conclusion, while these challenges are real, the potential benefits, a more inclusive, engaging, and profoundly effective mathematics education that serves a diverse student body, provide a compelling justification for the effort. By confronting these challenges directly, the academic community can move closer to an educational model that truly prepares students for the mathematical demands of the modern world.

8. Conclusion

This article has chronicled a journey across pedagogical cultures from the disciplined halls of classical mathematics education to the interactive classrooms of U.S. higher education. This cross-cultural passage revealed that the central challenge is not a binary choice between tradition and innovation, but a search for a synthesis that honors the indispensable strengths of both. The classical system provides the foundational rigor, procedural fluency, and logical stamina that are the bedrock of mathematical competence. The contemporary, inquiry-driven approach offers the essential tools for fostering conceptual understanding, student agency, and the confidence to engage with complex problems.

In response, this article has introduced the framework of pedagogical bilingualism and its practical embodiment, the Structured Inquiry Model. This is not a call for a simple compromise, but for a conscious, strategic integration where direct instruction and exploratory inquiry are seen as complementary forces. The case studies demonstrate that this approach can successfully transform rote exercises into conceptual inquiries, bridge preparation gaps without sacrificing rigor, and build resilient mathematical identities.

The implications of this work are clear: it calls for a reimagining of faculty development towards critical reflection and collaborative design, and for institutional cultures that support nuanced, hybrid teaching. While challenges of implementation exist, they are far outweighed by the promise of a more inclusive and effective mathematics education.

In conclusion, the future of mathematics education lies not in a clash of cultures, but in a conscious and creative integration of their strengths. By embracing pedagogical bilingualism, we can build learning environments that refuse to choose between competence and confidence, or between mastery and meaning. We can, instead, empower a generation of students who are not only skilled in the language of mathematics but are also fluent in the art of mathematical thinking.

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2. Clinical trial number: not applicable.
3. Ethics, Consent to Participate, and Consent to Publish: not applicable.

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