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Learning by Design: An Exploration of Mathematics Teachers' Practice-Based Transformation

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Abstract

This study explores how mathematics teachers undergo practice-based transformation in their pedagogy through the lens of design thinking. Using a qualitative case study approach, it follows the six-month journey of two in-service public school mathematics teachers as they take on the role of learning experience designers. Framed by the principles of design thinking, the research examines how teachers adapt, reimagine, and innovate their instructional practices. Data were collected through focus group discussions, semi-structured interviews, narrative reports, classroom artifacts, and reflective journals. The findings suggest that integrating design thinking supports the development of culturally responsive and contextually relevant pedagogical strategies that align with the values of equity and learner-centeredness in mathematics education. The study highlights the importance of teacher agency, empathy-driven design, and the integration of localized knowledge systems in enhancing students' mathematical learning experiences. In doing so, it contributes to ongoing discourse on professional identity, the teacher-as-designer paradigm, and the cultivation of practice-based knowledge in mathematics education

Introduction

Across the globe, mathematics education remains a critical and complex field, marked by ongoing efforts to improve student engagement, equity, and achievement. Mathematics is often viewed as a crucial subject, one that plays a role in shaping academic and professional opportunities, potentially limiting or enabling future choice. However, traditional approaches to mathematics teaching have long been criticized for rote memorization and a procedural approach at the expense of meaning-making, real-world application, and learner agency. The standards of the National Council of Teachers of Mathematics (2000) emphasize that mathematics instruction should extend beyond procedural fluency to cultivate conceptual understanding and support real-world application. In line with this, Freire (1970) pointed out how traditional mathematics instruction can diminish learner agency by treating students as passive recipients of procedures rather than active constructors of knowledge. Consequently, students from underserved

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and marginalized communities frequently experience mathematics as alienating, irrelevant, and inaccessible (Nasir et al., 2008).

In response to this global challenge, educational reform movements have called for a transformation of mathematics teaching and learning. The Organisation for Economic Co-operation and Development underscores the need for future-ready skills, including critical thinking, problem-solving, and collaboration skills that mathematics education is uniquely positioned to cultivate, if taught innovatively (OECD, 2018). Likewise, contemporary curricular reforms advocate for inquiry-based learning, culturally responsive pedagogy, and authentic assessment. Central to these shifts is the need for mathematics teachers to rethink their roles, not merely as transmitters of knowledge but as designers of meaningful, inclusive, and contextually grounded learning experiences.

This global call resonates deeply in the Philippine educational landscape. In recent years, the Department of Education (DepEd) has implemented numerous reforms, including the K to 12 Basic Education Curriculum, which emphasizes learner-centered pedagogy and performance-based assessment. However, despite these progressive policies, mathematics teaching in many public schools in the Philippines remains conventional and exam-oriented. Teachers often face systemic constraints: large class sizes, outdated materials, limited professional development, and high-stakes accountability measures (Second Congressional Commission on Education, 2025). These factors make pedagogical transformation difficult to sustain. Furthermore, many professional development programs focus on compliance and content delivery rather than innovation and reflective practice (SEAMEO INNOTECH, 2015). As a result, there is a growing disconnect between the aspirations of curricular reform and the realities of classroom practice.

Learning problems continued due to the absence of a systematic method for identifying empirically validated solutions to address these challenges (Abrigo & Orbeta, 2023). The situation is particularly salient in rural and resource-constrained regions such as Bukidnon in Northern Mindanao, Philippines. Mathematics teachers not only grapple with logistical and material challenges but also work within culturally diverse and multilingual communities. Despite these complexities, many teachers remain committed to improving their craft and meeting their students' needs. However, they often lack opportunities to critically reflect on their practice, experiment with new approaches, or engage in meaningful collaboration with peers. In this context, there is a pressing need for professional development models that are context-aware, participatory, and transformative.

One promising framework that addresses these challenges is design thinking, a human-centered, iterative problem-solving approach commonly used in fields such as engineering, architecture, and product development. In education, design thinking has gained traction as a way to empower teachers to reimagine their pedagogy, respond creatively to local challenges, and engage in continuous innovation (Razzouk & Shute, 2012). Unlike traditional models of professional development, design thinking is grounded in human-centered principles where results are tailored from the end-users' perspective (Bender-Salazar, 2023). It positions teachers not as passive implementers of the teaching-learning process but as reflective practitioners capable of designing, testing, and refining instructional strategies based on their students' unique needs and contexts.

The integration of design thinking into teacher professional development offers a paradigm shift, especially for mathematics education, where rigid routines and content-centric approaches often prevail. Several studies support the potential of design-based approaches in teacher development. For instance, Herrington and Reeves (2011) demonstrated how design principles can expand teachers' pedagogical practice and enhance student engagement. In the Australian context, Lockyer (2018) examined how both early career and experienced teachers engage in design practice to respond to complex classroom realities. Meanwhile, Meyer and Norman (2020) observed that traditional models of design education often fall short in preparing educators for the challenges of future-ready teaching, signaling a need for more robust, practice-based design experiences. By adopting the role of designers, teachers can critically examine their assumptions, frame pedagogical problems from multiple perspectives, and develop creative, equity-oriented solutions. Moreover, design thinking promotes a culture of risk-taking, collaboration, and resilience, which are qualities essential for sustainable educational change.

While literature on design thinking in education is growing, most studies focus on student creativity, school leadership, or curriculum design at the institutional level. There is limited research that examines how design thinking can serve as a framework for teacher

transformation, particularly in the day-to-day practices of classroom mathematics teaching. More so, few studies explore how teachers in low-resource, rural settings engage with design thinking as a reflective and generative tool. It represents a critical gap in the literature, one that this study seeks to address. This research investigates how in-service public school mathematics teachers in Malaybalay City, Bukidnon, Philippines, experience practice-based transformation through their engagement with a design thinking process. This study aims to explore how design thinking fosters teacher agency, promotes culturally responsive mathematics teaching, and generates practice-based knowledge within local school contexts.

The significance of this research is both practical and conceptual. Practically, it offers a replicable model for teacher professional development that is responsive to local realities and grounded in the lived experiences of educators. For school leaders, policymakers, and education advocates, the findings provide actionable insights into how to support and scale context-sensitive innovation. Conceptually, the study adds to the emerging discourse on teacher design agency—an area that intersects curriculum theory, educational change, and critical pedagogy. It challenges dominant narratives that view teachers as mere executors of top-down reforms and instead highlights their capacity to generate knowledge, lead change, and humanize mathematics education. By situating teachers as designers of learning rooted in empathy, reflection, and local knowledge, this research reaffirms the transformative power of teaching when guided by creativity, collaboration, and care.

Objectives

In general, the study aims to explore how in-service mathematics teachers experience practice-based transformation in their pedagogy through engagement in the design thinking process. Specifically, the study seeks to answer the following questions:

1. How do teachers use empathy to shift from general problems to learner-centered insights?
2. How do teachers develop self-awareness and reflective thinking through design thinking?
3. How do teachers make mathematics lessons culturally and contextually relevant?
4. How do teachers take risks and adapt their practices when trying new approaches?
5. How do teachers exercise agency and see themselves as creative designers of learning?

Conceptual Framework

The core premise of this study is that mathematics teachers undergo practice-based transformation when they engage in design thinking as a pedagogical orientation, shifting their roles from content transmitters to designers of learning experiences. Design thinking, as conceptualized by Brown (2009), emphasizes empathy, creativity, and iterative problem-solving as means of addressing complex challenges. Within the classroom context, its principles serve as the input and process catalyst of transformation. These principles involve empathy, or the deep understanding of learners' needs, contexts, and cultural backgrounds; the ability to define and frame instructional challenges in mathematics; the ideation of creative and localized solutions; the prototyping of culturally relevant lessons and activities; and continuous testing and reflection to refine practices (Razzouk & Shute, 2012).

Mediating this process is the cultivation of teacher agency and professional identity. Agency is understood as the capacity of teachers to act purposefully and constructively to direct their professional growth and adapt to changing contexts (Priestley, Biesta, & Robinson, 2015). Through design-oriented practices, teachers develop the agency to innovate, adapt, and resist rigid curricular structures. This transformation allows for the emergence of a teacher-as-designer identity (Penuel et al., 2007), expanding professional roles beyond traditional delivery and fostering reflexivity and critical awareness of their pedagogical approaches.

The outcomes of this framework manifest in two interrelated dimensions. The first is the development of culturally responsive and context-aware pedagogy, which emphasizes the integration of ethnomathematics and local knowledge systems in teaching (D'Ambrosio, 2001). Such practices align with Gay's (2010) principles of culturally responsive teaching, where equitable and inclusive tasks are designed to strengthen learner-centered instruction in ways that are relevant to community contexts. The second outcome is the generation of practice-based knowledge, which involves documenting classroom innovations, producing new insights into teacher professional development, and contributing to the broader discourse on design-oriented pedagogies in mathematics education.

Research Methodology

1. Research Design

This study employed a qualitative case study

design to examine the experiences of mathematics teachers undergoing a design thinking-driven pedagogical transformation. A case study approach is well-suited for obtaining an in-depth understanding of complex phenomena within their real-life contexts (Yin, 2018). Specifically, the research focused on two public school mathematics teachers who participated in a localized professional development initiative aimed at fostering pedagogical innovation through the design thinking process. The model used was adapted from Stanford University's Hasso Plattner Institute of Design, which involves five iterative stages: empathize, define, ideate, prototype, and test.

The case study design allowed for the detailed documentation of participants' reflections, instructional strategies, and design iterations over a sustained period. The study is grounded in the principles of constructivist and participatory inquiry, where knowledge is co-constructed through dialogue, reflection, and contextual practice. Rather than generalizing findings to a larger population, the study aims to generate practice-based insights and theoretical understandings that can inform future teacher professional development efforts, particularly in similar low-resource educational settings.

2. Population and Samples

The study was conducted in Malaybalay City, the capital of Bukidnon Province in Northern Mindanao, Philippines. The city hosts a blend of urban and rural public schools and serves a culturally diverse student population, including indigenous communities. Like many public education systems in the country, Malaybalay faces persistent challenges such as limited instructional resources, large class sizes, and minimal access to sustained, innovative professional development opportunities for teachers.

Two in-service mathematics teachers, one from a public elementary school and the other from a public secondary school, were purposively selected to participate in the study. The following criteria guided their selection: (a) a minimum of three years teaching experience in mathematics; (b) current involvement in delivering the K to 12 basic education curricula; (c) willingness to commit to a six-month professional learning program anchored on design thinking; and (d) demonstrated openness to pedagogical innovation and reflective practice.

The participants, referred to by the pseudonyms Ann and John, represented distinct teaching contexts within the division. Ann taught at a densely populated urban elementary school with limited resources, while John was assigned to a small rural secondary school serving a multicultural student body. This diversity in setting and level enabled the study to explore how the application of design thinking in mathematics pedagogy is shaped by varying school environments and teaching conditions.

3. Research Instrument

To document and analyze the pedagogical transformation of the participants, the study employed multiple qualitative data sources that provided both depth and breadth of insight. Focus Group Discussions (FGDs) were conducted at three critical stages (before, during, and after the design thinking process) to capture participants' collaborative reflections, meaning-making, and evolving perspectives throughout their professional learning journey. Semi-structured interviews were also carried out individually with each participant at the beginning and end of the six months. These interviews elicited rich personal narratives, motivations for participating in the program, perceived challenges, and reflections on pedagogical growth.

In addition, participants maintained reflective journals, which served as an ongoing record of their thoughts, emotions, instructional decisions, emerging design prototypes, and observations from their classrooms. Complementing these were narrative reports, which participants submitted at the conclusion of each design phase. These reports detailed their instructional actions, underlying rationales, outcomes, and areas for improvement. Finally, a range of classroom artifacts, including lesson plans, student work samples, photographs of activities, and teacher-created instructional materials, were collected to enrich the textual data and provide concrete evidence of practice-based transformation.

4. Collection of Data

The data collection process was carried out over six months and was closely aligned with the five phases of the iterative design thinking framework: empathize, define, ideate, prototype, and test. During the empathize phase (month 1), teachers engaged in identifying and mapping the existing challenges in their mathematics classrooms. Initial focus group discussions and individual interviews were conducted to surface their experiences and perceptions, while participants also began writing in their reflective journals to document emerging insights. In the define phase (month 2), these challenges were

reframed into actionable pedagogical problems. Participants submitted narrative reports outlining their diagnostic reflections, and some began drafting preliminary design prototypes.

The ideate phase (month 3) encouraged participants to envision ideal mathematics learning environments and to generate creative, context-responsive ideas for instructional improvement. This phase also included peer collaboration sessions, where participants exchanged ideas and refined their aspirations collectively. Moving into the prototype phase (month 4), teachers developed and piloted lesson prototypes based on their design concepts. Reflective journals played a critical role during this stage, capturing the real-time challenges, decisions, and instructional shifts as they unfolded. Finally, the test phase (months 5–6) involved full implementation of the refined lesson plans in the classroom setting. This phase concluded with final FGDs, semi-structured interviews, and submission of end-phase narrative reports, which captured the participants' reflections on the overall process and its impact on their teaching.

Throughout the study, the researcher served as both facilitator and observer, guiding discussions, conducting interviews, and gathering data while intentionally minimizing interference in the teachers' instructional decision-making. Ethical clearance was obtained, and informed consent was secured from all participants, ensuring adherence to research standards.

5. Data Analysis

The data were analyzed using thematic analysis, following the six-step framework proposed by Braun and Clarke (2006). The process began with familiarization, during which all audio recordings were transcribed, and the data, comprising interview transcripts, focus group discussions, reflective journals, narrative reports, and classroom artifacts, were read and re-read to develop an in-depth understanding of the content. In the initial coding phase, data segments were coded both inductively and deductively. Emergent codes were generated from the participants' actual language and experiences, while the phases of the design thinking framework informed pre-defined codes.

During the theme searching phase, similar codes were clustered into broader themes that highlighted patterns related to pedagogical shifts, reflective practice, and the integration of design thinking principles. These themes were then subjected to a reviewing process, where they were refined and validated for coherence across multiple participants and data sources. In the defining and naming phase, each theme was clearly articulated to reflect essential dimensions of practice-based transformation, such as teacher agency, contextual responsiveness, and empathy-driven instructional design. Finally, in writing the report, rich narrative descriptions, direct participant quotes, and illustrative examples were employed to present the findings and provide thick, contextualized insight into the participants' transformation journeys. To ensure the trustworthiness of the findings, the study employed methodological triangulation across data sources and conducted member-checking with participants to validate interpretations.

Results and Discussion

This section presents the key findings from the six-month design thinking professional learning engagement involving two in-service mathematics teachers, Ann and John. Their pedagogical journeys were examined through a thematic analysis of qualitative data, guided by the design thinking process of empathize, define, ideate, prototype, and test. The analysis focused on how the participants experienced practice-based transformation in their teaching approaches, beliefs, and professional identities.

Five major and interrelated themes emerged from the data:(1) Reframing Practice Through Empathy, which highlights the shift from surface-level problem identification to learner-centered insight; (2) Cultivating Reflective Teaching Dispositions, which underscores the development of critical self-awareness and evaluative thinking; (3) Contextualizing Mathematics through Local Knowledge, which reveals efforts to embed cultural and community relevance into lessons; (4) Risk-Taking and Iterative Pedagogical Innovation, which captures the participants' transition from traditional routines to experimental and adaptive practices; and (5) Enacting Teacher Agency and the Designer Identity, which demonstrates a transformation in how the teachers viewed their roles as empowered, creative professionals.

Each theme is elaborated in the succeeding sections and illustrated through narrative data drawn from focus group discussions, semi-structured interviews, reflective journals, narrative reports, and classroom artifacts. Together, these themes illuminate the complex and situated nature of pedagogical transformation enabled by the design thinking process.

Theme 1: Reframing Practice Through Empathy

One of the earliest and most significant shifts observed in the participants' pedagogical transformation

was the reframing of classroom challenges through empathy for students' perspectives. In the empathize phase of the design thinking process, both teachers initially identified problems in their practice, particularly low student engagement and poor academic performance. However, through structured reflection, empathy mapping, and collaborative dialogue, they moved beyond surface-level problem definitions toward a richer understanding of students' lived realities.

Ann, for example, initially framed her challenge as "students not participating during math class." Through empathy mapping exercises and reflective journaling, she uncovered a deeper issue—her lessons felt disconnected from her students' daily lives:

"Maybe they are not bored because math is hard, but because they cannot relate. I realize I was teaching mathematics concepts without meaning." (Reflective Journal, Week 2)

This recognition prompted Ann to critically examine the social and cultural roots of her teaching, including her own experiences as a learner in a formal school system where content is detached from context. Similarly, John reflected on how his reliance on English as the primary language of instruction posed a barrier to his multilingual, multicultural class:

"Some of my learners find it hard to learn Mathematics using the English language. I used to think they just did not want to answer. Now I see they need another way to understand the lesson." (Interview, Month 1)

Both teachers began their design thinking journey from a deficit-oriented stance, viewing disengagement as a result of laziness, low motivation, or poor discipline. The empathy phase catalyzed a shift toward a strengths-based, human-centered understanding of their students. It is consistent with Brown's (2009) human-centered design principle, which emphasizes beginning problem-solving with deep empathy for end-users, in this case, learners. The teachers' initial problem framing was symptomatic of a broader pattern in Philippine classrooms, where standard curricula and rigid assessments encourage teachers to focus on observable behaviors rather than the underlying causes of disengagement. The structured tools of design thinking—such as empathy mapping, reflective journaling, and learner interviews—functioned as what Schon (1984) calls reflective conversation with the situation. These methods enabled the teachers to uncover hidden factors: cultural disconnects, competing home responsibilities, linguistic barriers, and misalignments between students' lived realities and the mathematical content presented.

The findings suggest that empathy in teaching is not simply an attitude but a cognitive and pedagogical shift. For Ann, recognizing that her agricultural-community students were more likely to relate to math problems framed around crop yields or market prices led her to redesign her lessons for cultural relevance. For John, understanding the intimidation caused by English mathematical terminology inspired him to reframe concepts using indigenous metaphors and familiar vocabulary.

It mirrors Dewey's (1938) assertion that truly educative experiences link prior knowledge to new learning. It also resonates with Freire's (1970) critique of the banking system of education, where knowledge is deposited without regard for the learners' contexts. In reframing their practice, Ann and John moved toward what Gay (2010) calls culturally responsive teaching, in which learners' backgrounds are not incidental but central to curriculum and instruction.

The findings from this theme carry important implications for teaching practice. First, empathy must be recognized as a foundational skill in pedagogical design. Teachers need structured opportunities, such as design thinking exercises, to challenge their assumptions and meaningfully engage with students' realities. Without such processes, problem definitions often remain superficial, addressing symptoms rather than root causes. Second, localizing curriculum content is essential. By contextualizing instruction through local examples, native languages, and culturally relevant references, teachers can bridge the gap between abstract concepts and students' lived experiences, thereby enhancing engagement and comprehension.

Third, understanding learners' challenges as systemic and contextual rather than purely behavioral calls for a shift in assessment and feedback practices. Teachers are more likely to adopt formative and supportive feedback methods instead of punitive or deficit-based approaches when they view learning barriers through this lens. Finally, professional development should move beyond technical skill-building to promote deep reflection, cultural analysis, and student-centered problem framing. Such reflective inquiry empowers teachers to design learning experiences that are not only academically rigorous but also responsive to the diverse realities of their learners.

Ultimately, the empathy phase of the design

thinking process acted as a catalyst for pedagogical reorientation. By looking at learners through a human-centered lens (Carroll et al., 2010), Ann and John began to view teaching as a form of co-constructed meaning-making rather than one-way knowledge transmission. In the Philippine context, where curricular mandates often prioritize uniformity over local relevance, such shifts are essential to cultivating equitable and engaging learning environments.

Theme 2: Cultivating Reflective Teaching Dispositions

Throughout the design thinking process, both participants demonstrated a growing engagement in reflective practice, which emerged as a core driver of pedagogical transformation. The use of reflective journals, structured narrative reports, and peer dialogue enabled them to critically analyze their teaching decisions, surface underlying assumptions, and document shifts in their thinking. During the define phase, Ann noted how journaling revealed entrenched patterns in her instructional habits:

"I noticed I often stick to the textbook even when it does not work. Writing down what happened each week made me see this more clearly." (Reflective Journal, Week 4)

John, meanwhile, used his journal to deconstruct the unintended consequences of certain teaching practices:

"When I give drills, they are quiet but not thinking. They memorize, but forget. I am starting to ask—what kind of mathematics am I teaching them?" (Reflective Journal, Week 6)

Both teachers began to develop a habit of pausing, assessing, and rethinking their lessons, transforming reflection from a sporadic act into a professional disposition. This shift reflects Schon's (1984) notion of reflective practice as central to professional artistry, where teachers adapt strategies based on lived contexts rather than applying them routinely. The participants' reflective engagement also exposed critical misalignments between their pedagogical intentions and students' learning experiences. For example, both recognized a recurring reliance on procedural teaching despite their stated aim of fostering conceptual understanding. Importantly, reflection here was not limited to solitary introspection. Peer conversations and structured feedback loops embedded in the design thinking cycle functioned as collaborative mirrors, deepening self-awareness and broadening interpretive perspectives. It aligns with Vygotskian views of socially mediated learning, where dialogue with others amplifies individual cognition (McLeod, 2025).

The findings suggest that cultivating reflective dispositions requires more than encouraging teachers to "think about their practice." Reflection, when supported by systematic tools such as journals, narrative reports, and guided peer dialogue, becomes an intentional, iterative process of professional inquiry. Ann's awareness of her overreliance on textbooks and John's questioning of the cognitive value of drills represent critical turning points in their pedagogical thinking. Such realizations enable teachers to transition from reactive problem-solving to proactive instructional design grounded in evidence from their classrooms. Furthermore, the integration of reflection within the design thinking framework positioned it not as an optional afterthought but as a central mechanism for redefining problems and testing solutions. This iterative, inquiry-oriented stance is a hallmark of adaptive expertise (Zeichner & Liston, 1996), equipping teachers to navigate the complexity and uncertainty inherent in teaching.

The development of reflective teaching dispositions has several implications. First, professional learning programs should embed structured, sustained reflection into their design, moving beyond one-off workshops to create ongoing spaces for teachers to examine and interrogate their practice. Second, collaborative reflection should be emphasized alongside individual reflection, as peer dialogue can surface blind spots and expand interpretive frames. Third, reflection should be explicitly linked to pedagogical experimentation; teachers must not only identify problems but also act on their insights through iterative design and testing of new approaches. Finally, teacher evaluation systems should value reflective growth as a professional competency, recognizing that the ability to question and refine practice is as critical as content knowledge and instructional skill. Reflective practice served as a bridge between awareness and action, enabling participants to realign their teaching strategies with their educational values and students' needs. When institutionalized within a supportive professional learning model such as design thinking, reflection can shift from being a private, occasional activity to a collective, sustained driver of pedagogical transformation.

Theme 3: Contextualizing Mathematics through Local Knowledge

A third significant insight emerging from the study was the participants' intentional integration of local and cultural contexts into mathematics instruction, particularly during the ideate and prototyping phases of the design thinking process. Moving beyond reliance on standardized materials, both teachers began designing learning experiences that drew from students' lived environments and community knowledge, transforming mathematics from an abstract subject into a culturally grounded practice.

Ann, for example, designed a lesson on basic operations, addition and subtraction using rubber seeds, a common yet underutilized material in her locality. Students worked in groups to compute sums and differences by physically manipulating the seeds:

"They were more engaged when we used rubber seeds. They saw that math is fun. It made math feel practical and real." (Narrative Report, Phase 4)

John, meanwhile, created a lesson on integers using the community's local language. By presenting positive and negative numbers through familiar terms and everyday analogies, he noticed an immediate shift in student engagement:

"When we discussed mathematics concepts in their local language, their faces lit up. They saw that mathematics exists in their culture." (Focus Group, Phase 4)

These practices represent more than creative teaching strategies as they reflect a deliberate move toward culturally responsive pedagogy (Gay, 2010; Ladson-Billings, 1995), in which instruction validates learners' cultural identities while enhancing academic understanding. Through design thinking, both teachers were able to identify entry points where local resources, languages, and traditions could serve as authentic contexts for mathematical learning. Ann's use of agricultural materials for computation and John's integration of local language for conceptual explanation demonstrate how lesson design can affirm cultural heritage while promoting cognitive engagement.

This development challenges the persistent notion that mathematics is a universal, culture-free discipline. As Nasir et al. (2008) argue, mathematics learning is inevitably mediated by sociocultural factors, and failing to acknowledge this can alienate learners whose experiences are excluded from classroom discourse. In the Philippine context, where curriculum development is highly centralized and instructional materials are standardized, embedding local knowledge into teaching constitutes a subtle but meaningful form of pedagogical innovation and resistance.

Contextualizing mathematics was not merely a matter of making content relatable, it fundamentally altered the power dynamics of the classroom. By incorporating local resources and language, teachers positioned students as knowledge holders, recognizing their everyday experiences as legitimate sources of mathematical insight. This reorientation mirrors Freire's (1970) vision of education as a dialogic process, where knowledge is co-constructed rather than unilaterally delivered. Moreover, the shift underscores the potential of design thinking as a catalyst for reimagining curriculum. The development phase encouraged teachers to design lessons that emerged from empathy-driven insights and reflective self-analysis. In doing so, it bridged the gap between understanding students' needs and transforming that understanding into concrete instructional innovations.

The findings highlight several implications. First, culturally responsive mathematics instruction requires intentional design processes that go beyond superficial contextualization, embedding community resources and languages into core lesson structures. Second, teacher professional development should include training on local ethnomathematical practices, enabling educators to draw systematically from cultural and environmental contexts. Third, the use of local knowledge in mathematics challenges centralized curriculum models, suggesting the need for policy spaces that allow for contextual adaptation without compromising curricular integrity. Finally, contextualization is not only a pedagogical choice but an equity imperative as it affirms student identity, increases engagement, and fosters deeper conceptual understanding by linking abstract ideas to lived realities.

By integrating local culture and community knowledge into mathematics instruction, the participants demonstrated how design thinking can empower teachers to navigate between the demands of a standardized curriculum and the diverse realities of learners. In doing so, they redefined mathematics not as an imported set of abstract rules but as a living, contextually embedded discipline.

Theme 4: Risk-Taking and Iterative Pedagogical Innovation

A significant shift during the test phase of the design thinking process was the teachers' growing willingness to take instructional risks, depart from entrenched teaching routines, and embrace iteration based on real-time classroom feedback. The design thinking cycle—particularly the prototyping and feedback stages,

created an environment where experimentation was not only encouraged but normalized, thereby reducing the fear of failure that often constrains teacher innovation.

Ann vividly recalled her hesitation before implementing a rubber seed lesson designed to teach basic operations:

"I was scared it would be messy. What if they do not understand? But then I thought, I will never know if I do not try." (Interview, Month 5)

Her apprehension stemmed from the unpredictability of student responses in a more open-ended, context-based activity. However, after implementing the lesson, she observed higher student engagement, more confident participation, and a livelier class atmosphere. Encouraged by these outcomes, she revised and expanded the lesson into a two-week unit, further refining its activities to deepen conceptual understanding.

Similarly, John recounted his experience piloting a math-and-culture lesson that used local language to contextualize integer operations:

"The first time, some parts did not go smoothly. Students got confused with the math terms, but they got the idea. I adjusted the activity the next day." (Reflective Journal, Week 8)

For John, the initial confusion among students was not a deterrent but a diagnostic moment, highlighting areas for linguistic and conceptual scaffolding. His quick adjustments demonstrated not only flexibility but also the growing habit of iterating lesson design in response to learners' needs.

These narratives reflect a key transformation that the teachers moved from a mindset of perfectionism, waiting for a flawless lesson to one of curiosity and continuous improvement. The iterative stance they developed mirrors Kalantzis and Cope's (2010) learning by design principle, in which trial, error, and revision are central to the knowledge-creation process. In this view, risk-taking becomes an inherent part of innovation rather than an occasional leap of faith.

The study also affirms the value of safe failure environments in teacher professional learning. Within the design thinking framework, both Ann and John reframed unsuccessful lesson moments as formative feedback rather than final judgments. It reflects Hattie's (2008) assertion that visible learning occurs when errors are recognized as opportunities for growth, not evidence of inadequacy. By treating failed or imperfect prototypes as necessary steps in refinement, the teachers demonstrated professional resilience, a quality particularly crucial in mathematics education, where the content's perceived rigidity often inhibits pedagogical change (Schoenfeld, 2014).

The implication for practice is significant that fostering a structured, low-stakes space for experimentation can embolden teachers to try novel strategies, especially in disciplines like mathematics that traditionally emphasize procedural correctness over creative risk-taking. By adopting iterative cycles of design, implementation, reflection, and refinement, educators can shift toward more adaptive and responsive instruction, ultimately enhancing both student engagement and conceptual mastery.

Theme 5: Enacting Teacher Agency and the Designer Identity

The most profound transformation observed across the study was the participants' emergence as agents of change and designers of learning experiences. This shift signaled not just an adjustment in teaching strategies, but a redefinition of professional identity from passive implementers of prescribed content to active, reflective creators of culturally resonant pedagogy.

Ann's reflection in the final focus group captured this transformation vividly:

"Before, I always followed what was given. Now I feel I can create. I know my students, I know what works here, and I can make learning better."

John's words echoed the same identity shift:

"Design thinking reminded me that teaching is not just following plans. It is about planning with purpose, with heart, and with our learners in mind."

These statements reveal a movement toward what Penuel et al. (2007) describe as teacher agency as a sense of ownership and authorship over professional practice, which is essential for sustainable educational change. By engaging in the cyclical stages of defining problems, ideating solutions, prototyping, testing, and refining lessons, both teachers began to see themselves not merely as transmitters of content but as architects of learning environments responsive to their students' realities.

This identity shift is not isolated; it is deeply connected to the preceding themes. The empathy-driven reframing laid the foundation by making teachers more attuned to learners' lived experiences. Their reflective dispositions and contextualized learning designs reinforced their confidence in adapting lessons to fit their local context. The risk-taking and iterative experimentation provided them with experiential

evidence that innovation could succeed, even when imperfect. Together, these earlier developments deconstructed the long-held perception of teaching as a fixed, prescriptive activity, replacing it with a dynamic, adaptive, and creative practice.

Importantly, the development of a designer identity aligns with Hatchuel's (2009) notion of expansive design capability, where design is not merely a set of techniques but a mindset grounded in adaptive problem-solving, empathy, and intentionality. This mindset proved particularly empowering in the low-resource, standardized testing-driven context of Philippine public schools, where teachers often feel constrained by rigid curricula.

The emergence of agency was also relational, shaped through interactions with students, colleagues, and the researcher-facilitator. It supports Biesta et al.'s (2015) argument that teacher agency is not an inherent trait but an evolving capacity that flourishes in supportive, dialogic environments. The collaborative design thinking process served as both a structure and a catalyst for this growth, offering teachers the time, trust, and tools to experiment without punitive consequences.

A particularly significant dimension of this agency was the integration of ethnomathematics as a lens for pedagogy. By embedding mathematics in familiar cultural narratives, objects, and practices, the teachers not only reframed how mathematics was communicated but also re-situated themselves as cultural mediators of knowledge. Ethnomathematics became both a tool for contextualizing content and a means of self-understanding, allowing teachers to connect their professional practice to their own lived experiences, community histories, and sense of purpose.

Thus, the enactment of teacher agency was not solely about producing innovative lessons. It involved a self-reflective acquisition of professional identity, where teachers recognized their capacity to make meaningful changes in students' lives. It is perhaps the most lasting transformation: the realization that mathematics teaching can be dynamic, empathetic, and culturally grounded when teachers see themselves as designers or shapers, not just delivering, the learning experience.

The broader implication for professional development is clear: when teachers are positioned as designers within an inquiry-based, practice-embedded framework, they become more creative, contextually responsive, and empowered. Such a shift challenges traditional top-down training models, calling instead for co-constructed, reflective, and iterative professional learning that leverages teachers' contextual expertise.

Conclusion

This study explored the practice-based transformation of two in-service mathematics teachers through their engagement in a six-month professional learning program grounded in the design thinking process. Anchored in rich qualitative data from focus groups, interviews, reflective journals, narrative reports, and classroom artifacts, the study revealed how design thinking enabled the teachers to rethink their pedagogy, challenge long-held assumptions, and reframe classroom challenges as opportunities for innovation.

The findings point to five interrelated themes: (1) reframing practice through empathy, (2) cultivating reflective teaching dispositions, (3) contextualizing mathematics through local knowledge, (4) risk-taking and iterative pedagogical innovation, and (5) enacting teacher agency and the designer identity. These themes highlight how design thinking served not merely as a set of creative tools but as a transformative framework for cultivating professional growth, deep reflection, and meaningful classroom change.

Most notably, the study demonstrates that teachers, when positioned as designers of learning rather than mere implementers of curriculum, develop greater confidence, creativity, and ownership over their practice. The pedagogical shifts that occurred were not externally imposed but emerged from within, fueled by empathetic engagement with students, collaboration with peers, and sustained reflection. The case of Ann and John illustrates that pedagogical transformation is most impactful when it is context-sensitive, teacher-led, and supported by structured opportunities for experimentation, feedback, and iteration.

In contexts where teachers often face rigid curricular demands, limited resources, and diverse learner needs, this study affirms the potential of design thinking to empower teachers to respond adaptively and meaningfully to the realities of their classrooms. Ultimately, the study reaffirms that sustained pedagogical change is not a product of training alone, but of empowered professionalism rooted in care, creativity, and critical engagement.

Suggestions

Grounded in the findings of this study, several key suggestions are proposed to enhance teacher

development, promote pedagogical innovation, and advance mathematics education, particularly in resource-constrained and culturally diverse contexts. First, design thinking should be meaningfully integrated into teacher professional development programs, both for in-service and pre-service teachers. Instead of relying solely on top-down training models, professional learning should empower teachers to explore their classroom challenges, ideate potential solutions, and prototype and refine instructional innovations. Embedding design thinking within continuing professional development fosters a more responsive, reflective, and creative teaching practice.

Second, schools and education institutions should institutionalize reflective teaching practices by providing regular and structured opportunities for teachers to document, share, and discuss their reflections. Reflective journals, peer coaching, and collaborative dialogues must be viewed not as optional or peripheral tasks, but as vital to the ongoing growth of teachers. School administrators can support this by allocating time within the school schedule for meaningful reflection and professional conversation. Third, there is a pressing need to support the contextualization of mathematics instruction using culturally responsive and locally grounded content. Teachers should be encouraged and given autonomy to infuse local realities, indigenous knowledge systems, and community-based problems into their lesson designs. Such contextualization enhances student engagement, promotes inclusivity, and bridges abstract mathematical concepts with learners' lived experiences.

Fourth, education stakeholders must promote a school culture that values experimentation, innovation, and risk-taking in the classroom. Teachers should be provided with a safe and supportive environment where they can test new ideas without fear of failure or penalization. Establishing innovation hubs, lesson study groups, or peer learning communities can help sustain this culture. Furthermore, celebrating and recognizing small-scale pedagogical innovations can encourage a growth mindset and collective learning among educators. Fifth, it is essential to redefine teacher roles to emphasize agency and creativity. Teachers should be positioned not merely as implementers of prescribed curriculum, but as co-designers of learning who actively shape classroom experiences in response to student needs. Institutional policies, leadership narratives, and performance evaluation systems should reflect this expanded identity. When teachers are trusted and treated as professionals with expertise, they are more likely to invest deeply in meaningful pedagogical transformation.

Finally, the study calls for further research and multi-sector collaboration to expand the impact of teacher design thinking. Cross-disciplinary studies can explore how design thinking manifests in other subject areas and grade levels. Longitudinal research may also uncover how sustained engagement in design thinking shapes teacher identity and student outcomes over time. Partnerships among universities, schools, and local education authorities can enable the scaling of teacher-as-designer models while grounding them in the realities of diverse educational contexts. Collectively, these recommendations aim to support an educational ecosystem where teachers are not only empowered to transform their practice but also recognized as key drivers of innovation and equity in mathematics education. By anchoring teacher development in empathy, reflection, and contextual responsiveness, we move closer to building a transformative and inclusive educational future.

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