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# Navigating the AI-TPACK Frontier: Challenges of Mathematics Teachers in Integrating Artificial Intelligence into Classroom Instruction

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**ABSTRACT**

This qualitative study explored challenges mathematics teachers encounter in integrating Artificial Intelligence within the TPACK framework (AI-TPACK) in the Division of Cotabato, Philippines. Using descriptive-qualitative design, in-depth interviews and focus group discussions were conducted with purposively selected DepEd mathematics teachers who use AI in teaching. Data were analyzed via thematic analysis, yielding two Global Themes: (1) Technological Capacity and Resource Constraints in AI Integration, encompassing limited access to AI tools, lack of AI literacy, and insufficient professional development; and (2) Pedagogical and Instructional Challenges in AI-TPACK Integration, encompassing difficulty aligning AI with mathematics pedagogy and concerns about AI undermining students' mathematical reasoning. These findings reveal simultaneous infrastructure, competency, and pedagogical barriers requiring systemic institutional responses. The study contributes the concept of 'double deprivation' -- wherein teachers lacking physical AI access simultaneously lack the pedagogical experience needed to develop AI-TPACK competencies -- and provides the qualitative foundation for evidence-based intervention and policy development.

**Keywords:** AI Integration Challenges, Mathematics Teaching, Qualitative Research, Thematic Analysis, AI-TPACK, Professional Development, Philippines

## 1. Introduction

While Phase 1 quantitative findings established that mathematics teachers demonstrate high AI-TPACK levels, quantitative data cannot illuminate the lived experiences that shape -- and obstruct -- AI integration in daily classroom practice. Qualitative inquiry is essential for explaining and contextualizing numerical findings, providing the experiential texture that surveys cannot capture (Creswell & Plano Clark, 2011). This study addresses the What are the challenges DepEd teachers face in integrating AI-TPACK in mathematics teaching?

## 2. Methodology

### *2.1 Design and Participants*

A descriptive-qualitative design was employed (Kim et al., 2017). Criterion-based purposive sampling (Etikan et al., 2016) selected mathematics teachers who were permanent employees for at least one year and actively used AI tools in teaching. Structured interviews followed a 22-item expert-validated guide. Recordings were transcribed verbatim, with Filipino/Bisaya responses translated to English.

### *2.2 Thematic Analysis and Trustworthiness*

Data were analyzed using Braun and Clarke's six-phase thematic analysis protocol: familiarization, coding, theme searching, theme review, theme definition, and report production (Peel, 2020). Trustworthiness was established through credibility (member checking), conformability (expert validation), transferability (thick descriptions), and dependability (coding audit trail) (Bliese & Hanges, 2014).

## 3. Findings

Thematic analysis yielded two (2) Global Themes, five (5) Organizing Themes, and nine (9) Basic Themes, as summarized in Table 1.

**Table 1. Generated themes on the challenges of DepEd teachers face in integrating AI-TPACK in mathematics teaching**

| Global Themes | Organizing Themes | Basic Themes |
|---|---|---|
| **GT1: Technological Capacity & Resource Constraints** | Limited Access to AI & Digital Tools | Absent AI platforms in schools<br>Unstable internet & no ICT equipment<br>Personal device dependence |
| | Lack of Technical Skills & AI Literacy | Limited AI tool familiarity<br>Low confidence using AI platforms |
| | Insufficient Professional Development Opportunities | No AI-focused training programs |
| **GT2: Pedagogical & Instructional Challenges** | Difficulty Integrating AI into Mathematics Pedagogy | AI-objective misalignment<br>Difficulty designing AI activities<br>No lesson planning strategies |
| | Concerns: AI vs. Math Content Mastery | AI-induced overreliance on solutions<br>Weak conceptual understanding<br>AI-curriculum misalignment |

### *Global Theme 1: Technological Capacity and Resource Constraints*

**Organizing Theme 1.1 — Limited Access to AI and Digital Tools**

The most pervasive challenge across all informants was the absence of adequate technological infrastructure. Teachers reported AI platforms as unavailable or inaccessible, classrooms lacking computers and projectors, and internet connectivity as unreliable.

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| **Teacher 3** | *"In our school, we rarely have access to AI tools for teaching. Most of the platforms we hear about are not available for us to use in the classroom."* |

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| **Teacher 6** | *"Our classroom does not even have computers available, so using AI-based applications in teaching becomes challenging."* |

Dependence on personal devices as compensation reflects individual teacher agency while simultaneously exposing systemic institutional deficits. Li (2025) termed this 'institutional unreadiness' -- the structural gap between AI potential and the physical conditions in which teachers must operate. Yuan et al. (2023) similarly documented that facilitating conditions are the strongest predictors of educational technology adoption, overshadowing individual attitudinal variables.

**Organizing Theme 1.2 — Lack of Technical Skills and AI Literacy**

Even where AI tools were available, teachers reported limited functional competency in deploying them instructionally -- a gap between social media awareness of AI and classroom application.

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| **Teacher 5** | *"Alam ko man na mag AI tools [I know about AI tools], but I am not very familiar with how they work or how to use them in my lessons."* |

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| **Teacher 4** | *"I am hesitant to use AI tools because I am not confident in using it."* |

This competency-confidence gap confirms Mollo (2025): prior technological exposure is a prerequisite before AI-specific application confidence develops. Lu and Wang (2021) demonstrated that pre-service technological experiences are foundational to TPACK development, suggesting AI literacy must be embedded in initial teacher education rather than retrofitted through in-service programs.

**Organizing Theme 1.3 — Insufficient Professional Development**

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| **Teacher 6** | *"I have no training that specifically [focuses on] using artificial intelligence in teaching mathematics."* |

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| **Teacher 11** | *"Most of our seminars focus on general teaching strategies, but AI integration is rarely discussed."* |

Koh and Divaharan (2011) established that structured instructional models are essential for building TPACK competencies; Madanat et al. (2024) showed that more-trained teachers demonstrate higher readiness for digital adoption.

***Global Theme 2: Pedagogical and Instructional Challenges***

**Organizing Theme 2.1 — Difficulty Integrating AI into Mathematics Pedagogy**

Even among teachers with basic AI familiarity, aligning AI-generated content with learning competencies, transforming AI outputs into structured activities, and embedding AI in lesson plans remained formidable challenges.

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| **Teacher 3** | *"I sometimes use AI to generate explanations, but I am not sure if it really matches the objectives of my mathematics lesson."* |

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| **Teacher 6** | *"I still lack strategies on how to include AI when planning my mathematics lessons."* |

These tensions reflect AI-TPACK as a wicked pedagogical design problem: effective integration requires resolving the inherent friction between what AI tools produce and what sound mathematics pedagogy demands (Miralles-Martinez et al., 2019).

**Organizing Theme 2.2 — Concerns: AI Use vs. Mathematics Content Mastery**

A pedagogically distinctive finding was teachers' concern that AI efficiency in providing solutions may undermine the development of mathematical reasoning, independent problem-solving, and conceptual understanding in students.

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| **Teacher 2** | *"Some students rely too much on AI to solve the problems instead of trying to analyze the steps themselves."* |

| | |
|---|---|
| **Teacher 2** | *"Kon ang AI amo ang nagahatag sang step-by-step nga sabat, mahimo nga indi na maghatag sang oras ang mga estudyante sa paghunahuna sing kritikal parte sa problema." [When AI gives the step-by-step answer, students may not take the time to think critically about the problem.]* |

This AI-reasoning trade-off represents a pedagogically novel concern receiving limited attention in the literature. Effective AI integration requires teachers to scaffold AI as a learning partner rather than a solution oracle, explicitly guiding students to engage critical thinking alongside AI-provided outputs (Oguejiofor, 2025).

## 4. Discussion

The two Global Themes operate at different but mutually reinforcing levels. GT1 -- Technological Capacity -- operates institutionally and cannot be resolved by individual teacher effort. GT2 -- Pedagogical Challenges -- operates at the professional knowledge level. Their intersection reveals the 'double deprivation' of AI integration: teachers lacking physical AI access simultaneously lack the practical experience through which pedagogical AI competencies are developed. This double deprivation produces compounding disadvantage -- institutional barriers prevent the experience that builds competence, and competency absence reduces confidence to seek access when it becomes available.

Addressing both dimensions simultaneously requires systemic responses: infrastructure investment at the institutional level; AI-specific professional development at division and regional levels; and pedagogically grounded AI integration frameworks -- emphasizing AI-as-scaffold over AI-as-solution -- at school and classroom levels.

## 5. Conclusion

This study provides the first comprehensive qualitative account of AI-TPACK integration challenges among mathematics teachers in a Philippine public school division. The two Global Themes and their subordinate organizing and basic themes collectively map the experiential landscape of AI integration barriers and point toward specific, actionable reforms. The 'double deprivation' concept contributes a novel theoretical lens for understanding AI integration challenges in resource-constrained educational contexts globally.

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