

## **From Intended to Enacted: A Situated Analysis of TPACK-in-Action Through Video-Stimulated Recall in Geometry Classrooms**

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### **Abstract:**

The integration of digital technology into mathematics classrooms remains inconsistent despite the development of the Technological Pedagogical Content Knowledge (TPACK) framework. This study investigates the persistent "know-do gap" by proposing a conceptual framework consisting of intended, enacted, and reflected TPACK. A qualitative multiple-case study was conducted with four secondary mathematics teachers in East Java, Indonesia. Data were triangulated from lesson plans, dual-camera classroom observations, and video-stimulated recall (VSR) interviews. Findings reveal a significant discrepancy: while teachers designed sophisticated technology-rich lessons, 65% of planned activities were shortened or abandoned during enactment. This regression to traditional instruction was primarily driven by excessive dual cognitive load and real-time classroom management pressures. VSR successfully uncovered teachers' tacit reasoning, serving as a cognitive trigger for reflective improvement. The study concludes that TPACK is a situated and dynamic competence rather than a static body of knowledge. Implications suggest that professional development should move beyond technical training toward structured video-reflection cycles to develop teachers' adaptive orchestration and real-time decision-making skills.

**Keywords:** TPACK-in-action, video-stimulated recall, geometry learning, teacher cognition, technology integration

### **Introduction**

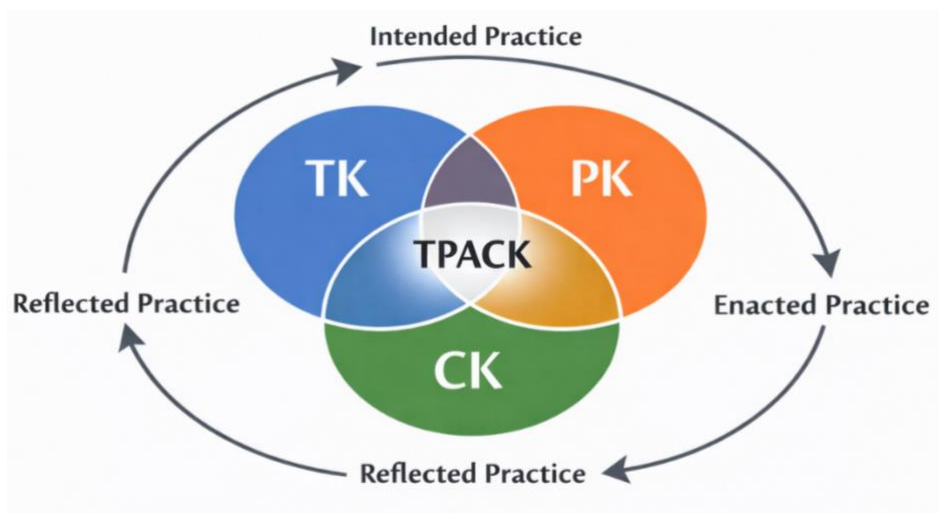
The rapid development of digital technology has reshaped mathematics education worldwide, shifting the role of technology from a mere supporting medium to a sophisticated cognitive tool that facilitates visualization, exploration, and conceptual reasoning (Laborde, 2001; Niess, 2011; Graham, 2011). In modern mathematics classrooms, particularly in the domain of geometry, effective technology integration is no longer viewed as a static set of technical skills. Instead, it is conceptualized as a form of instructional orchestration, where teachers must



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dynamically coordinate digital tools, pedagogical objectives, and real-time student interactions to foster deep mathematical understanding (Niess, 2011; Graham, 2011).

The Technological Pedagogical Content Knowledge (TPACK) framework has emerged as the preeminent model for understanding teacher competence in this digital era (Mishra & Koehler, 2006). However, contemporary scholars argue that TPACK should be reconceptualized through the lens of situated cognition. This perspective posits that TPACK is not a fixed body of declarative knowledge but a dynamic, situated competence that is manifested through the continuous negotiation between teacher cognition and classroom context. To capture this complexity, this study proposes a triadic framework that distinguishes between intended, enacted, and reflected practices, as illustrated in Figure 1.



**Figure 1.** Conceptual framework of TPACK-in-action and the relationship between intended, enacted, and reflected practices.

Despite the robustness of the TPACK framework, empirical evidence consistently reveals a persistent "know-do gap". Many teachers report high levels of perceived TPACK competence, yet they struggle to enact technology meaningfully during actual instruction, a challenge that remains central in recent mathematics education research (Hanifah et al., 2024; Hanifah et al., 2025). Contextual constraints—such as time pressure, curriculum coverage, and classroom management—often cause teachers to abandon their technological plans and revert to conventional, teacher-centered methods (Bennison & Goos, 2010). Consequently, technology integration often remains superficial or presentation-oriented rather than transformative (Harris & Hofer, 2011).

In the Indonesian context, the importance of TPACK in teacher education is increasingly emphasized. Recent investigations show that teachers' ability to design technology-integrated lessons varies widely and requires systematic, practice-based support (Hanifah et al., 2024; Masriyah et al., 2024). Technology-supported models,

particularly those utilizing GeoGebra, have shown promise in improving instructional effectiveness (Masriyah et al., 2024). The mechanism behind this success lies in GeoGebra’s capacity to serve as a cognitive tool; its dynamic environment allows teachers to visualize and manipulate abstract geometric relationships in real-time, helping them bridge technological possibilities with specific pedagogical content goals. Furthermore, emerging digital innovations, such as flipped classrooms supported by artificial intelligence (AI), are being explored to enhance conceptual understanding among preservice teachers (Masriyah et al., 2025).

Geometry instruction provides a particularly fertile ground for examining TPACK-in-action and teacher noticing. Geometry requires high levels of spatial reasoning and the fluid coordination of multiple representations (Laborde, 2001; Hanifah et al., 2018). From a cognitive standpoint, the difficulties teachers face during enactment can be interpreted through cognitive load theory. Teaching with dynamic geometry software requires the simultaneous management of content delivery, technological operation, and classroom interaction. Excessive mental demands often lead to cognitive overload, prompting teachers to simplify instruction by abandoning digital tools to regain control (Sweller, 1988).

To move beyond the limitations of self-report surveys, which often fail to capture the nuances of classroom decision-making, this study utilizes Video-Stimulated Recall (VSR). VSR allows teachers to review lesson recordings and articulate the tacit professional reasoning behind their spontaneous actions (Lyle, 2003; Nguyen et al., 2013). This methodological shift is essential for revealing the situated practices and "missed opportunities" that occur during instruction.

The primary novelty of this research lies in its systematic triangulation of intended, enacted, and reflected TPACK, shifting the focus from static measurement to process-oriented analysis. By documenting what teachers actually do and why they make those decisions, this study addresses critical gaps in the existing literature, as summarized in Table 1.

**Table 1.** Comparison of Research Trends and the Study’s Niche

| Focus                     | Typical Method    | Limitation         | Gap Addressed                      |
|---------------------------|-------------------|--------------------|------------------------------------|
| TPACK perception          | Survey            | Self-report bias   | No classroom evidence              |
| Lesson design competence  | Document analysis | Planning only      | Enactment unclear                  |
| Student outcomes          | Experimental      | Product-focused    | Process ignored                    |
| Cognitive/spatial studies | Tests             | Student focus only | Teacher actions missing            |
| Current study             | Observation + VSR | —                  | Captures enacted & reflected TPACK |

Based on these considerations, this study investigates TPACK-in-action during secondary geometry teaching using a qualitative multiple-case design. Specifically, it examines how teachers translate planned integration into classroom action and the factors influencing the discrepancies between intention and enactment. The study addresses the following research questions:

1. How is TPACK manifested during real-time geometry instruction?
2. What discrepancies exist between intended and enacted technology use?
3. What cognitive and contextual factors explain these discrepancies?
4. How does Video-Stimulated Recall reveal teachers' tacit pedagogical reasoning?

### Research Methods

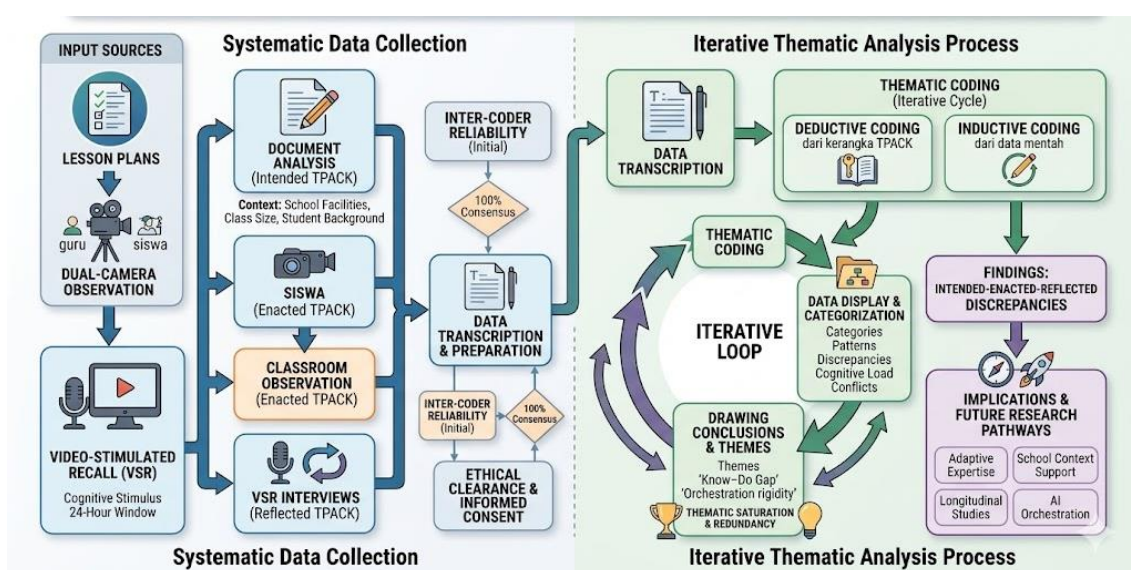
This study employed a qualitative multiple-case study design to investigate the situated enactment of Technological Pedagogical Content Knowledge (TPACK) during secondary geometry instruction. Epistemologically, a qualitative multiple-case approach was selected to prioritize analytical depth and rich contextualization over statistical generalizability, as the study sought to explore real-time instructional decisions and reflective reasoning that cannot be adequately captured through surveys or experimental methods (Creswell & Poth, 2018; Yin, 2018). The selection of four distinct cases (T1–T4) was instrumental for theoretical replication, where patterns of technology abandonment and the "know–do gap" could be examined across various classroom environments to strengthen the robustness of the findings (Stake, 2006). The participants consisted of four secondary mathematics teachers from four public junior high schools in East Java, Indonesia, selected through purposive sampling. The criteria included: (1) at least five years of teaching experience, (2) prior proficiency in using GeoGebra in geometry lessons, and (3) a willingness to undergo intensive observation and reflective interviews. To provide full transparency regarding the instructional environment as requested by reviewers, Table 2 details the specific class sizes, technological facilities, and student backgrounds for each participant.

**Table 2.** Participant Profiles and School Contextual Factors

| Teacher | Experience | Class Size  | Tech Facilities in School               | Student Background                     |
|---------|------------|-------------|---|--|
| T1      | 12 Years   | 32 Students | Projector, Wi-Fi, Student Tablets       | Urban, middle-socioeconomic            |
| T2      | 8 Years    | 36 Students | Projector, Shared Computer Lab          | Mixed-socioeconomic, moderate literacy |
| T3      | 15 Years   | 34 Students | Interactive Whiteboard, Wi-Fi           | Urban, high-achieving students         |
| T4      | 6 Years    | 30 Students | Projector, BYOD (Bring Your Own Device) | Suburban, mixed-ability levels         |

Data were collected from three triangulated sources to capture the intended, enacted, and reflected dimensions of TPACK. First, lesson plans were analyzed to

identify intended TPACK (planned technology integration). Second, classroom teaching was recorded using a dual-camera setup; one camera focused on the teacher’s pedagogical orchestration while the other captured student interactions and software interfaces to document real-time enactment. Third, Video-Stimulated Recall (VSR) interviews were conducted within 24 hours after each lesson to ensure the validity of the reflective process and minimize memory bias (Lyle, 2003; Nguyen et al., 2013). During these sessions, selected video segments served as a cognitive stimulus, enabling teachers to articulate the tacit professional reasoning behind their spontaneous instructional decisions. The systematic flow of these data collection and analysis procedures is illustrated in Figure 2.



**Figure 2.** Systematic flow of data collection and the iterative thematic analysis process

Data analysis followed a rigorous multi-stage thematic analysis procedure (Miles et al., 2014). To ensure methodological transparency, a hybrid coding approach was adopted, combining deductive coding—to classify practices into the "intended-enacted-reflected" framework—and inductive coding to identify emerging themes such as dual cognitive load, classroom management pressures, and technical glitches. To ensure the trustworthiness of the analysis and address inter-coder reliability, the researchers independently coded 20% of the total data set, resolving discrepancies through iterative discussion until a 100% consensus on the codebook was reached. Thematic saturation was monitored throughout the cross-case analysis and was considered achieved when additional data from the participants provided redundant patterns, confirming that the thematic categories regarding the "know–do gap" were well-developed and no new insights were emerging. This study adhered to strict ethical standards; ethical clearance was obtained from the institutional review board, and all participants provided written informed consent. To further enhance credibility,

member checking was conducted, allowing participants to review transcripts and preliminary interpretations to confirm that the findings accurately represented their pedagogical reasoning and intentions.

## Results and Discussions

This section presents the findings according to the research questions and integrates empirical evidence with theoretical interpretation. Data from lesson plans, classroom observations, and Video-Stimulated Recall (VSR) interviews were triangulated to explain how Technological Pedagogical Content Knowledge (TPACK) was enacted during geometry instruction. The presentation follows three sequential phases: intended practice, enacted practice, and reflected practice.

### Intended TPACK: Technology Integration at the Planning Stage

The evaluation of Intended TPACK moved beyond a descriptive summary by applying three specific evaluative criteria: (1) Curricular Alignment, measuring how technology supports specific geometric properties; (2) Pedagogical Sophistication, distinguishing between teacher-led demonstration and student-led exploration; and (3) Cognitive Demand, assessing whether the technology was used to simplify tasks or deepen conceptual reasoning. Document analysis revealed that all four teachers (T1–T4) achieved high levels of conceptual alignment, as evidenced by the transition from traditional "instructionalist" methods to "constructivist" designs.

To provide a concrete visualization of these designs as suggested by the reviewer, consider the task developed by T1 involving dynamic cross-sections. In this activity, students were intended to use dynamic sliders in GeoGebra to manipulate a cutting plane across a 3D pyramid. By adjusting the slider, students could observe in real-time how the shape and area of the resulting cross-section changed dynamically relative to its height from the base to the apex. This specific example illustrates how technology was intended to function as a cognitive tool for exploratory learning rather than a passive visual aid. To demonstrate the analytical process, Table 3 provides specific coding examples extracted from the lesson plans.

**Table 3.** Analytical Indicators and Coding Examples of Intended TPACK

| Teacher | Planned Activity       | Evaluative Indicator | Coding Example (Excerpt from Lesson Plan)  | Intended TPACK Level |
|---------|------------------------|----------------------|--|----------------------|
| T1      | GeoGebra cross-section | Cognitive Tool       | "Students manipulate the slider to observe how the cross-section area changes dynamically relative to the height." | High (Exploratory)   |
| T2      | 3D rotation model      | Visual Reasoning     | "Use 360-degree rotation simulation to help students identify hidden edges in complex polyhedra."                  | Moderate (Visual)    |

|    |                           |                   |   |                          |
|----|---------------------------|-------------------|---|--------------------------|
| T3 | Interactive worksheet     | Student Agency    | "Guide students to construct their own polygons using the tool to test conjectures about interior angles."          | High (Constructivist)    |
| T4 | Transformation simulation | Conceptual Bridge | "Show the effect of reflection on coordinates through side-by-side dynamic display of points and algebraic values." | Moderate (Demonstration) |

These analytical indicators suggest that teachers’ Intended TPACK was not merely about "using tools," but about pedagogical orchestration where technology served as a cognitive trigger. For instance, T1’s plan was coded as "High-Exploratory" because the teacher explicitly designed a task where students—not the teacher—manipulated variables to observe geometric invariants. This level of planning confirms that teachers possessed a sophisticated conceptual understanding of the interaction between technology, pedagogy, and geometry content (TPACK) before entering the classroom.

**Enacted TPACK: Discrepancies During Classroom Implementation**

Although lesson plans indicated strong technological integration, classroom observations revealed frequent discrepancies between intended and enacted practices. Across the four observed lessons, 11 instances of technology abandonment were recorded. To provide a more granular analysis, these instances were mapped across the lesson phases—Introduction, Main Exploration, and Discussion/Conclusion—to identify where instructional regression typically occurred.

**Table 4.** Temporal Analysis of Discrepancies Between Planned and Enacted Practices

| Teacher | Time  | Lesson Phase  | Planned Activity        | Enacted Action (Regression)       |
|---------|-------|---------------|-------------------------|-----------------------------------|
| T1      | 18:25 | Main Activity | GeoGebra simulation     | Switched to lecture explanation   |
| T2      | 34:12 | Exploration   | Dynamic modeling        | Closed software due to confusion  |
| T3      | 41:08 | Discussion    | Student-led exploration | Reverted to teacher demonstration |
| T4      | 52:30 | Conclusion    | Interactive task        | Manual whiteboard drawing         |

Analysis of these instances reveals that the Main Exploration phase was the most critical point for technology regression (6 out of 11 cases). In this phase, the dual demand of managing dynamic software while simultaneously facilitating spontaneous student inquiries created an unsustainable cognitive load. Furthermore, during the Discussion phase (4 cases), teachers frequently abandoned planned student manipulation in favor of teacher-led demonstrations to ensure lesson completion within the allotted time. Regression in the Introduction phase was rare (1 case) and was primarily attributed to technical setup issues rather than pedagogical shifts.

Overall, approximately 65% of planned technology activities were shortened or replaced by traditional explanations. These results indicate that enacted TPACK was

substantially lower than intended TPACK, confirming that conceptual knowledge of digital tools does not automatically translate into successful classroom orchestration under situational pressure.

### Cognitive and Contextual Factors Influencing Technology Regression

VSR interviews provided a "thinking-aloud" perspective that clarified why teachers abandoned technology despite their high-level planning. A deeper analysis reveals that the reported cognitive overload was not a monolithic pressure but originated from specific tensions between TPACK domains and orchestration conflicts.

**Table 5.** Analytical Mapping of Cognitive Overload and Orchestration Conflicts

| Teacher | Source of Overload                           | TPACK Domain Conflict | Analytical Interpretation   |
|---------|--|-----------------------|---|
| T2      | Software manipulation vs. Student inquiries  | TK vs. PK Conflict    | Orchestration Conflict: The teacher struggled to maintain "pedagogical noticing" while simultaneously managing the technical interface of GeoGebra. |
| T3      | Extended software time vs. Lesson completion | TK vs. CK Conflict    | Contextual Pressure: Technological operations (TK) were perceived as a threat to curriculum coverage (CK), leading to "time-saving" regression.     |
| T1      | Student distraction vs. Interactive task     | PK Dominance          | Management Priority: The need for classroom control (PK) overrode the intended technological integration.   |

Analysis of these excerpts indicates that the regression primarily stemmed from a failure in real-time orchestration. For instance, Teacher T2's confusion was not due to a lack of TK (technical skill) or CK (geometric knowledge) in isolation, but rather a TK-PK collision. The cognitive demand of navigating the dynamic software interface simultaneously with the pedagogical demand of answering spontaneous student questions exceeded the teacher's mental capacity. In this state of overload, the teacher instinctively reverted to the most "stable" and "low-load" tool—the physical whiteboard.

Similarly, the regression in T3 and T1 illustrates how contextual factors (time and student behavior) force a trade-off. Teachers perceived that the high "transactional cost" of technology-mediated exploration compromised their ability to meet traditional instructional goals (e.g., finishing the syllabus or maintaining silence). This suggests that technology regression is a rational survival decision made when teachers perceive that the complexity of orchestration threatens the stability of the classroom ecosystem (Sweller, 1988; Bennison & Goos, 2010).

**Reflected TPACK: Role of Video-Stimulated Recall**

VSR interviews functioned as a metacognitive mirror, allowing teachers to transcend descriptive recall and engage in a critical evaluation of their "hidden" instructional reasoning. A deeper analysis of the 10 recorded reflective statements reveals that the nature of these reflections was not merely descriptive but shifted along a spectrum from defensive to transformative, leading to a significant reframing of pedagogical beliefs.

**Table 6.** Metacognitive Analysis: From Defensive to Transformative Reflection

| Teacher | Nature of Reflection       | Metacognitive Shift                          | Evidence of Pedagogical Reframing  |
|---------|----------------------------|--|--|
| T2      | Transformative             | From "Technical Focus" to "Student Noticing" | "I realized that my fear of the software made me ignore that students were actually successfully exploring."                                     |
| T3      | Defensive → Transformative | From "Blaming" to "Control-Questioning"      | Initially blamed the syllabus, but later admitted: "I dominated because it felt safer, not because it was better for learning."                  |
| T1      | Transformative             | Adaptive Expertise Development               | "Now I see a specific 'hinge point' where I could have pivoted. Next time, I will use that student's question as a trigger to re-open GeoGebra." |

The analysis shows that VSR prompted a reframing of pedagogical beliefs regarding the "teacher's role." Before the reflection, teachers held a latent belief that they must remain in control of the technological interface to ensure "efficiency." However, through the video review, they experienced a metacognitive conflict: they saw visual evidence of student engagement that they had missed in real-time. This conflict triggered transformative reflection, where teachers like T3 and T2 moved away from defensive justifications (e.g., blaming time or student distraction) toward an acknowledgment of their own "orchestration rigidity."

Furthermore, these reflections indicate the nascent development of adaptive expertise. Instead of just following a rigid plan (*routine expertise*), teachers began to identify "pivotal moments" in the video where they could have acted differently. T1's ability to articulate a specific alternative strategy for a future scenario is a hallmark of adaptive expertise, suggesting that Reflected TPACK acts as a bridge that prepares

teachers to handle the unpredictability of technology-rich geometry classrooms more flexibly in the future.

### Discussion and Implications

The findings of this study provide robust empirical evidence that Technological Pedagogical Content Knowledge (TPACK) is manifested as a dynamic and situated performance rather than a static or stable body of declarative knowledge. While the participating teachers demonstrated high-level Intended TPACK at the planning stage—designing sophisticated, GeoGebra-enhanced geometry lessons—their actual classroom implementation revealed frequent and significant discrepancies. This "know-do gap" suggests that technology integration is not merely a product of conceptual knowledge but is a result of a complex, real-time negotiation between the teacher's cognition and the immediate classroom context. Such results support and extend previous literature which argues that self-reported TPACK competence frequently overestimates actual classroom enactment (Harris & Hofer, 2011; Schmidt et al., 2009). By moving beyond the "planning phase" and documenting the "enactment phase," this study confirms that possessing the knowledge to design a technology-rich lesson does not automatically translate into the ability to navigate the "orchestration dance" required in a live classroom setting.

The observed regression from student-led exploratory instruction to traditional teacher-led explanations highlights a persistent struggle for control and efficiency under situational pressure. Across the observed cases, approximately 65% of planned technology activities were either shortened or abandoned, particularly during the Main Exploration and Discussion phases. This regression is a critical indicator of an orchestration conflict, where the simultaneous demands of managing dynamic geometry software (TK), addressing spontaneous student questions (PK), and ensuring the geometric properties are accurately visualized (CK) exceed the teacher's cognitive capacity. From the lens of cognitive load theory, the teachers in this study experienced a "transactional cost" of technology that they found unsustainable during peak instructional moments. Consequently, reverting to the whiteboard became a rational survival decision—a way to reduce the dual cognitive load and regain instructional stability (Sweller, 1988; Bennison & Goos, 2010). This finding is particularly relevant in geometry instruction, where spatial reasoning already imposes high mental demands; adding the layer of software manipulation creates a cognitive bottleneck that often forces a return to conventional, "safer" teaching methods.

Theoretical implications of this study suggest a necessary shift in how TPACK is conceptualized. Rather than viewing it as a static Venn diagram of knowledge domains, TPACK should be understood as a triadic, process-oriented construct consisting of intended, enacted, and reflected practices. The use of Video-Stimulated Recall (VSR) proved indispensable in this regard, acting as a "metacognitive mirror" that allowed teachers to transcend defensive reporting and engage in transformative

reflection. The VSR sessions revealed that many instances of technology abandonment were "automatic" or "reactive." However, the act of watching their own teaching triggered a reframing of pedagogical beliefs, where teachers moved from blaming external constraints (like time or student behavior) to recognizing their own "orchestration rigidity." This process is essential for developing adaptive expertise—the ability to identify "hinge points" in a lesson where a teacher can pivot their technology use flexibly rather than following a rigid, and ultimately fragile, plan (Lyle, 2003; Nguyen et al., 2013).

Compared with previous Indonesian studies that focused primarily on lesson design quality or student outcomes (Hanifah et al., 2024; Masriyah et al., 2024), this research provides a more microscopic view of the "situatedness" of technology integration. It situates the teacher's decision-making within the unique constraints of the Indonesian junior high school context—such as large class sizes and varying tech literacy—demonstrating that even with the advent of AI-supported and flipped classroom innovations (Masriyah et al., 2025), the teacher's real-time pedagogical noticing remains the most critical factor. The findings emphasize that Reflected TPACK serves as the vital bridge; without it, the discrepancy between what a teacher intends to do and what they actually achieve remains invisible, hindering long-term professional growth.

Practically, these results imply that teacher professional development (PD) must move beyond technical training focused on software operation. If the bottleneck of technology integration is orchestration conflict, then training must focus on classroom orchestration skills, time management, and adaptive decision-making. Future PD programs should incorporate structured video-based reflection where teachers can analyze "critical incidents" of technology use. By identifying exactly where and why regression occurs—whether it be a TK-PK collision or a CK-related time pressure—teachers can develop the specific metacognitive strategies needed to maintain technology-rich instruction under pressure. Furthermore, school-level support must address the contextual pressures identified here; manageable class sizes and flexible scheduling are not just administrative details but are essential "cognitive supports" that give teachers the mental space required for meaningful technology enactment. In conclusion, viewing TPACK as a situated, reflective process rather than a static skill set provides a more realistic and actionable pathway for improving mathematics education in the digital age.

## Conclusions and Suggestions

This study concludes that Technological Pedagogical Content Knowledge (TPACK) in geometry instruction is not a static body of declarative knowledge but a situated and dynamic performance shaped by real-time negotiation between cognition and context. While teachers consistently demonstrated high-level Intended TPACK at the planning stage, the Enacted TPACK observed in the classroom frequently suffered

from "instructional regression." This regression is triggered by orchestration conflicts, where the simultaneous demands of managing dynamic geometry software (TK), addressing student inquiries (PK), and ensuring content accuracy (CK) create an unsustainable cognitive load. The findings confirm that the "know-do gap" is a result of these situational pressures rather than a lack of conceptual understanding.

The primary theoretical contribution of this research is the conceptualization of TPACK as a triadic, process-oriented construct consisting of intended, enacted, and reflected practices. By introducing the Reflected TPACK dimension through Video-Stimulated Recall (VSR), this study provides a new lens to capture the metacognitive awareness that remains invisible in traditional survey-based measurements. This framework offers a more accurate assessment of teacher competence, positioning reflection as the essential bridge that transforms "routine expertise" (following a plan) into "adaptive expertise" (flexibly pivoting during orchestration conflicts). Methodologically, the study demonstrates that VSR acts as a "metacognitive mirror," triggering a reframing of pedagogical beliefs from teacher-centric control toward student-centric noticing.

Based on these conclusions, several specific suggestions are offered. Teacher professional development must shift its focus from isolated technical training toward classroom orchestration pedagogy. Programs should prioritize "simulated orchestration" and time-management strategies that help teachers handle the "transactional cost" of technology without abandoning exploration. Furthermore, schools should move beyond providing hardware to fostering collaborative video-reflection communities, where teachers can collectively analyze "critical incidents" of technology enactment to build shared adaptive strategies.

For future research, this study identifies specific avenues to deepen the field's understanding of the "know-do gap." First, longitudinal studies are needed to examine how consistent VSR cycles over a full academic year influence the long-term development of adaptive expertise and the reduction of technology regression. Second, research should investigate the orchestration of AI-integrated geometry environments, specifically how tools like ChatGPT or automated feedback systems influence the teacher's cognitive load during real-time enactment. Finally, future investigations could utilize eye-tracking technology in conjunction with VSR to provide a "micro-analysis" of teacher noticing, identifying the exact visual triggers that lead a teacher to either sustain or discontinue technology use during complex geometric explorations.

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