

Review

Mathematics Teachers' Pedagogical Content Knowledge in Strengthening Conceptual Understanding in Students with Learning Disabilities: A Practice-Based Conceptual Synthesis

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Abstract

Students with learning disabilities (LD) often struggle to develop deep, transferable conceptual understanding in mathematics due to cognitive and processing challenges, underscoring the relevance of instruction grounded in strong teacher pedagogical content knowledge (PCK). This issue is critical given widening post-pandemic achievement gaps and increased expectations for conceptual understanding in inclusive classrooms. Although many studies document effective mathematics interventions for students with LD, relatively few examine how teachers' PCK functions in these classrooms. In contrast, general education research highlights the importance of PCK for conceptual learning. This manuscript bridges these studies by examining how insights from broader PCK research may inform instruction for students with LD. This manuscript presents a practice-based conceptual synthesis of research on mathematics teachers' PCK, integrating findings from special education and mathematics intervention literature with classroom vignettes and practitioner examples. The synthesis highlights how core PCK components—content knowledge, understanding of student thinking and misconceptions, and instructional strategies—may support early conceptual understanding in students with LD, emphasizing multiple representations, error analysis, and routines that promote generalization through distributed practice. Implications for practice, professional development, and future research are discussed, offering practice-informed pathways to support inclusive mathematics instruction for students with LD.

Keywords: learning disabilities; conceptual understanding; mathematics education; pedagogical content knowledge; teacher preparation



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1. Introduction

A persistent mathematics achievement gap exists for students with mathematics learning disabilities (LD), predating the COVID-19 pandemic and widening in its aftermath, particularly compared to other subjects (Fitz, 2025). Data from the National Assessment of Educational Progress (NAEP) indicate that the average mathematics score for eighth-grade students with disabilities declined from 247 in 2019 to 243 in 2022, remaining unchanged through 2024 (National Center for Education Statistics, 2024). U.S. mathematics performance also continues to lag behind many other nations on international assessments such as the Program for International Student Assessment (PISA) and the Trends in International

Mathematics and Science Study (TIMSS, [Organization for Economic Co-operation and Development, 2023](#)).

Classroom instruction plays a central role in shaping students' mathematics achievement ([Fitz, 2025](#)). Early conceptual understanding—recognizing relationships among mathematical ideas and connecting concepts across representations—is foundational for advanced mathematical skills, flexible problem solving, and long-term retention ([Kaskens et al., 2020](#); [McCoy et al., 2017](#); [National Research Council \[NRC\], 2001](#); [Rittle-Johnson & Schneider, 2015](#)). For example, students who develop reasoning strategies in early elementary grades rather than relying on rote memorization demonstrate improved fact fluency and efficiency ([Baroody et al., 2009](#); [L. S. Fuchs et al., 2008](#)). Conceptual knowledge enables learners to see mathematics as an interconnected system rather than a collection of disconnected facts, linking concepts through tools such as number lines, manipulatives, and pictorial models ([National Research Council \[NRC\], 2001](#)). When procedures are learned with understanding, students make fewer errors, learn more efficiently, and retain knowledge longer ([Rittle-Johnson & Schneider, 2015](#)).

Despite its importance, students with LD often struggle to build conceptual understanding, especially when instruction prioritizes procedural fluency over reasoning. ([Coddington et al., 2010](#); [Geary, 2004](#); [Gersten et al., 2009](#)). Challenges include deficits in number sense, difficulties with spatial representations, and limited cognitive processing efficiency ([Coddington et al., 2010](#); [Jordan et al., 2003](#)). Particularly, students with dyscalculia—a specific learning disability affecting numerical understanding—often lack the conceptual foundations necessary to apply procedures flexibly or transfer skills across contexts ([Geary, 2004](#)). Supporting conceptual understanding is therefore critical for promoting skill generalization and improving the efficiency and flexibility of mathematics performance, which can reduce reliance on effortful computation and support students' mathematical confidence ([L. S. Fuchs & Fuchs, 2002](#); [Gersten et al., 2022](#)). With over 2.3 million students receiving services under the [Individuals with Disabilities Education Act \(2004\)](#) for LD, and 4–7% estimated to have dyscalculia, addressing these is a pressing educational priority (Learning Disabilities Association of America).

Improving mathematics outcomes for students with LD requires access to highly qualified educators who are skilled in evidence-based instructional practices and capable of adapting instruction to meet diverse learning needs ([Clements et al., 2023](#); [Gersten et al., 2009](#)). Additionally, teachers must be able to identify conceptual errors, promote generalization, and make informed instructional decisions that deepen understanding—practices essential to mathematics proficiency ([Clements et al., 2023](#)). Research further indicates that targeted interventions integrating conceptual understanding with explicit instruction and structured practice are particularly effective ([Burns et al., 2015](#); [National Research Council \[NRC\], 2001](#)).

Pedagogical Content Knowledge (PCK), first articulated by [Shulman \(1986\)](#), provides a framework for translating mathematical knowledge into effective instruction. PCK integrates deep content knowledge, awareness of student thinking and misconceptions, and instructional strategies—including modeling, mathematical discourse, multiple representations, scaffolding, and structured practice ([Ball et al., 2008](#); [Penso, 2002](#)). Strong PCK is foundational for elementary and special education teachers to address the unique needs of students with LD ([Fukaya et al., 2025](#)). While general education research highlights PCK's role in shaping conceptual learning (e.g., [Depaepe et al., 2013](#); [Fukaya et al., 2025](#); [Li & Copur-Gencturk, 2024](#); [D. I. Miller et al., 2022](#)), comparatively few studies examine PCK in classrooms serving students with LD (e.g., [Güven et al., 2022](#); [Misri et al., 2025](#)), revealing a critical gap.

This manuscript addresses this gap through a practice-based conceptual synthesis that integrates research on mathematics teachers' PCK with findings from special education and mathematics intervention literature (Bryant et al., 2011; Dennis et al., 2016; L. S. Fuchs et al., 2008; Powell et al., 2023; Xin et al., 2022). Using classroom vignettes and practitioner-oriented examples, we examine how strengthening core PCK components can support conceptual understanding in students with LD, focusing on multiple representations, systematic error analysis, and instructional routines that foster generalization. By linking research-informed principles to real-world instructional decision-making, this work provides actionable guidance for teacher learning, professional development (PD), and inclusive, effective mathematics instruction.

2. PCK in Mathematics Education

2.1. Defining PCK

PCK (Shulman, 1986, 1987) provides a framework for understanding the specialized knowledge teachers use to transform subject matter into instruction that is comprehensible, meaningful, and cognitively accessible to learners. In mathematics education, PCK extends beyond general content knowledge—which encompasses understanding mathematical concepts, procedures, and relationships—to the intersection of content and pedagogy (Ball et al., 2008; H. C. Hill et al., 2008). It includes a deep understanding of mathematical concepts, awareness of how students typically think about and misconstrue these concepts, and knowledge of instructional strategies that promote conceptual development (Shulman, 1986).

Shulman (1986, 1987) first introduced the concept of PCK to capture the idea that effective teaching requires more than knowing content; it involves presenting ideas strategically, anticipating student misconceptions, and designing tasks that support understanding. Building on this framework, Ball et al. (2008) highlighted content-specific pedagogical reasoning in mathematics, including selecting representations, sequencing concepts, and adjusting instruction in response to student thinking. Thus, PCK functions as a bridge between knowing mathematics and knowing how to teach it, enabling teachers to make deliberate instructional decisions that support meaningful learning, particularly for elementary students who struggle with abstract reasoning or conceptual understanding (Ball et al., 2008; National Research Council [NRC], 2001; Rittle-Johnson & Schneider, 2015; Shulman, 1986). While distinct from general content knowledge, PCK depends upon strong content understanding to orchestrate effective, conceptually grounded instruction.

2.2. Understanding PCK in the Context of Students with LD

High-quality mathematics instruction for students with LD requires intentional, well-designed instructional supports to access and engage with mathematical content, balancing grade-level rigor with cognitive accessibility (Fukaya et al., 2025; Lee et al., 2021). This instructional balance depends heavily on teachers' professional judgment and pedagogical expertise (A. H. Miller et al., 2025; NCTM & CEC, 2020). Students with LD often face challenges such as difficulty with working memory, abstract reasoning, number sense, and transferring knowledge across contexts (Grigaliūnienė et al., 2025). Teachers' PCK provides the framework for anticipating these learning barriers, selecting appropriate representations, sequencing instruction, scaffolding learning, designing conceptually rich instruction, and promoting meaningful understanding (A. H. Miller et al., 2025).

3. Core Domains of Mathematics Teachers' PCK

As illustrated in Figure 1, contemporary models of mathematics PCK emphasize three interrelated domains (Ball et al., 2008): (a) content knowledge for teaching mathemat-

ics, including understanding mathematical structures, relationships, and developmental progressions; (b) knowledge of student thinking, including common misconceptions and learning trajectories; and (c) knowledge of instructional strategies and representations, encompassing specialized methods for sequencing, modeling, and scaffolding mathematical ideas.

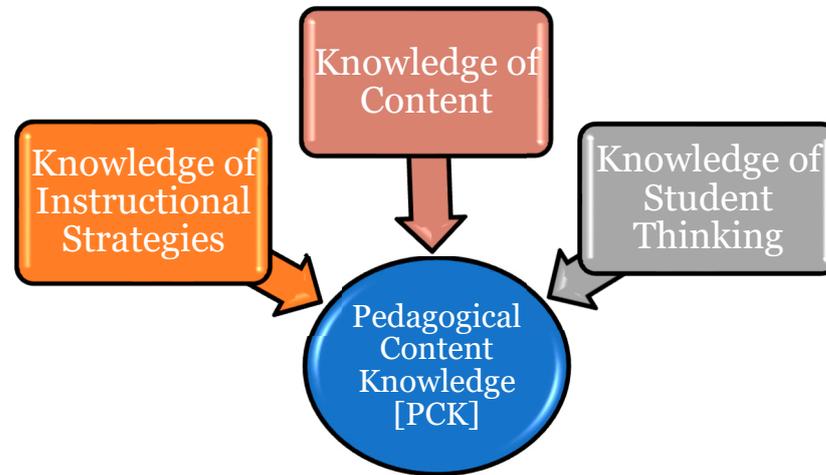


Figure 1. Pedagogical Content Knowledge Domains.

When enacted cohesively, these domains enable teachers to respond dynamically to students' reasoning, address misconceptions, and foster conceptual understanding alongside procedural fluency (Grigaliūnienė et al., 2025). In classrooms serving students with LD, these PCK domains are not isolated knowledge sets but mutually reinforcing tools that guide teachers' moment-to-moment instructional decision-making.

3.1. Knowledge of Content

Content knowledge forms the foundation of effective mathematics instruction. It extends well beyond procedural fluency to include a deep understanding of mathematical concepts, structures, and relationships, as well as how these ideas develop over time and across grade levels (Ball et al., 2008; H. C. Hill et al., 2008). Teachers with strong content knowledge recognize underlying mathematical "big ideas," such as place value, equivalence, additive reasoning, multiplicative reasoning, and proportional reasoning, and understand how these ideas interconnect—for example, understanding multiplication as combining equal groups rather than merely recalling multiplication facts (Juárez-Ruiz et al., 2025; Tzur & Xin, 2022).

For students with LD, robust content knowledge is particularly critical. Surface-level instruction can exacerbate difficulties with generalization and transfer (Gersten et al., 2022). Teachers must be able to decompose complex concepts into coherent instructional sequences by deliberately selecting examples, representations, and explanations that make mathematical relationships visible and concrete (Smith & Stein, 2011; Xin et al., 2025). In practice, this may involve selecting representations that highlight structure (e.g., number lines for magnitude, arrays for multiplication), explicitly linking visual and symbolic representations, or emphasizing conceptual relationships, such as the inverse nature of addition and subtraction or the multiplicative relationship that connects multiplication and division. Instruction grounded in content knowledge supports students with LD in building durable conceptual foundations rather than relying on fragile procedural shortcuts (Bryant et al., 2011; L. S. Fuchs et al., 2008; Xin et al., 2022).

3.2. Knowledge of Student Thinking and Misconceptions

Understanding how students conceptualize mathematical ideas, including common errors and incomplete conceptions, is central to PCK (Ball et al., 2008; Shulman, 1986). Misconceptions are particularly prevalent and enduring among students with LD, often stemming from prior instruction that emphasized procedures without meaning, or from inherent difficulties with abstraction and working memory (Lin et al., 2025; Lin & Riccomini, 2025).

Teachers with knowledge of student thinking use formative assessment and classroom discourse to surface reasoning (Xin et al., 2016, 2019), interpret errors as informative indicators of conceptual gaps rather than as mistakes, and adjust instruction responsively to support conceptual restructuring (Copur-Gencturk et al., 2025).

Examples of common misconceptions among students with LD include:

- Misinterpreting the equal sign as a directive to compute rather than as a symbol of equivalence (Booth et al., 2017; Knuth et al., 2006), for example, when presented with an equation such as $3 + 4 = 5 + 2$, students may compute only the left-hand side, revealing a limited understanding of relational equality.
- Place-value confusion (Van de Walle et al., 2019), such as reading 42 as “4 + 2” or reversing digits as 24, indicates an incomplete understanding of the base-ten system.
- Additive reasoning applied to multiplication (e.g., interpreting 4×3 as $4 + 3$), reflecting an incomplete grasp of multiplicative relationships (L. S. Fuchs et al., 2016).
- Overgeneralization of patterns without conceptual grounding (Van de Walle et al., 2019), such as assuming all odd numbers end in “1,” further illustrates how students may misapply learned rules without conceptual grounding.

These misconceptions are frequently reinforced when instruction prioritizes memorization or procedural compliance over conceptual understanding (Rittle-Johnson et al., 2015). Instruction that anticipates these misconceptions and explicitly addresses them through scaffolds and representations reduces cognitive load and supports meaningful understanding (Gersten et al., 2009; Powell et al., 2023; Xin et al., 2023).

3.3. Knowledge of Instructional Strategies

The third PCK domain involves selecting, sequencing, and implementing instructional strategies that support conceptual understanding. Effective practices include: (a) multiple, coordinated representations, such as concrete manipulatives, visual models, symbolic notation to make abstract ideas accessible (Dennis et al., 2016; Lesh et al., 1987; National Research Council [NRC], 2001); (b) explicit instruction, characterized by clear modeling, logical sequencing, guided practice, immediate feedback, distributed review, and cumulative scaffolds (Archer & Hughes, 2011; Doabler et al., 2021); and (c) evidence-based routines, such as Concrete–Representational–Abstract (CRA) sequences (Bruner, 1966; Milton et al., 2018), think-aloud modeling (Davey, 1983; Trocki et al., 2015), Number Talks (Parrish, 2010), incremental rehearsal (IR; Burns, 2005; Tucker, 1989), and structured error analysis (Buswell & Judd, 1925; Lin et al., 2025; Radatz, 1979; Tularam & Hassan, 2025). These strategies are highlighted in this manuscript because they have strong empirical support for promoting conceptual understanding and transfer (e.g., Archer & Hughes, 2011; Bruner, 1966; Davey, 1983; Parrish, 2010) and they illustrate how teachers’ PCK can inform the purposeful selection, sequencing, and adaptation of instructional moves to support diverse learners, including students with LD, even though research specifically examining PCK in this population is limited.

Explicit instruction supports students with LD by breaking complex mathematical tasks into manageable components and making underlying concepts transparent (Archer & Hughes, 2011). When combined with guided practice and distributed review, explicit instruction helps reduce cognitive overload and minimizes the persistence of misconcep-

tions (Doabler et al., 2021). The CRA approach further strengthens conceptual links by guiding students from hands-on manipulatives (e.g., base-ten blocks) to visual models (e.g., arrays, number lines) and finally to abstract symbols (Bouck et al., 2017; Witzel et al., 2003). Think-aloud modeling makes mathematical reasoning explicit, supporting gradual independence (Trocki et al., 2015). Number Talks are brief, structured discussions in which students share mental strategies that support flexible thinking and provide teachers with insight into students' reasoning (Parrish, 2010). Purposeful prompts (e.g., "How did you decide on that strategy?"), guided hints (e.g., "What happens if we group these as tens?"), scaffolding, and feedback enable teachers to maintain responsiveness while gradually transferring responsibility for reasoning to students (Hattie & Timperley, 2007; Vygotsky, 1978). IR is an evidence-based strategy that uses simple flashcards to gradually introduce new skills or facts, alongside high percentages of previously mastered items, to support retention (Burns, 2005; Tucker, 1989). Error analysis routines, in which students examine and correct intentionally flawed solutions, further promote conceptual understanding by encouraging students to articulate reasoning and confront misconceptions directly (Smith & Stein, 2011).

Teachers' PCK guides the timing, selection, and sequencing of these strategies, ensuring that instruction is responsive to students' conceptual needs rather than procedurally rigid. Differentiation through tiered tasks, flexible grouping, and adaptive technologies further enhances access while maintaining rigor for students with LD (Roberts & Inman, 2021).

3.4. Integrating PCK Domains to Support Conceptual Understanding

Integrating content knowledge, knowledge of student thinking, and instructional strategies enables teachers to design equitable and effective mathematics instruction (Fukaya et al., 2025; Shulman, 1986). Within a practice-based conceptual synthesis, PCK functions as the mechanism through which research-based strategies are translated into meaningful classroom practice. Teachers leverage PCK to identify misconceptions early, select and sequence representations purposefully, scaffold learning to promote coherent, transferable understanding, and balance procedural skill development with conceptual reasoning (Ball et al., 2008; Lesh et al., 1987; Rittle-Johnson & Schneider, 2015; Vygotsky, 1978). This integration is particularly critical for students with LD, whose learning trajectories often require adaptive scaffolding, strategic pacing, and deliberate connections across representations (Bouck et al., 2017; D. Fuchs et al., 2014).

Math Knowledge + Pedagogical Skill → Effective Math Instruction

4. Empirical Evidence on Teachers' PCK and Mathematics Instruction

Empirical research increasingly indicates that students with LD in mathematics benefit from structured, conceptually oriented instruction (e.g., Kroesbergen & Van Luit, 2003) and that PCK mediates the effectiveness of evidence-based instructional practices and students' conceptual learning outcomes, particularly in the elementary grades (Ball et al., 2008; Depaepe et al., 2013; Misri et al., 2025). Although a substantial body of research has identified evidence-based instructional practices for improving mathematics outcomes for students with LD (e.g., Bryant et al., 2011; L. S. Fuchs et al., 2008; Gersten et al., 2009; Xin et al., 2025), fewer studies have examined the teacher knowledge mechanisms that support the effective enactment of these practices in authentic classroom contexts. To further contextualize these findings, the following subsections review evidence from reviews and studies, highlighting teachers' PCK in mathematics instruction and its relevance for students with LD.

4.1. Evidence from Meta-Analyses and Systematic Reviews

Research on intensive and tiered mathematics interventions for students with LD provides strong evidence for the central role of teacher PCK in promoting effective learning. Meta-analyses indicate that interventions incorporating explicit instruction, strategy modeling, cumulative review, and frequent formative assessment yield moderate to large effects for elementary students with LD in mathematics (Dennis et al., 2016; D. Fuchs et al., 2014). However, the success of these interventions depends heavily on teachers' ability to enact them with conceptual clarity and instructional flexibility. For example, L. S. Fuchs et al. (2015) emphasized that teachers' interpretation of student errors and selection of instructional responses significantly influence intervention outcomes, highlighting the value of PCK in distinguishing between procedural mistakes and conceptual misunderstandings, adapting representations, and scaffolding learning to promote transfer.

Complementing these findings, meta-analyses and systematic reviews examining the relationship between teachers' mathematics knowledge and student achievement consistently report positive associations between topic-specific PCK and student outcomes (H. C. Hill et al., 2008). Depaepe et al. (2013) concluded that PCK is most strongly related to student achievement when it encompasses knowledge of students' misconceptions, instructional representations, and formative assessment practices—components that are particularly salient for students with LD. More recent syntheses reinforce this conclusion. Fukaya et al. (2025) reported a positive correlation between teachers' PCK and student academic performance across grade levels, while Grigaliūnienė et al. (2025) found that many instructional approaches address conceptual or combined conceptual–procedural difficulties but often lack explicit alignment with students' underlying misconceptions or learning challenges, underscoring the importance of PCK in tailoring instruction.

Experimental evidence further suggests that strengthening teachers' PCK yields greater instructional impact than focusing solely on content knowledge. For instance, Fukaya et al. (2024) found significantly stronger effects for PCK-focused interventions compared to content-only interventions, highlighting the added value of pedagogical reasoning and instructional decision-making. Within the special education literature, Gersten et al. (2009) synthesized findings from mathematics intervention studies for students with LD and identified explicit modeling, guided practice, systematic scaffolding, and progress monitoring as features associated with improved outcomes.

Crucially, the effective implementation of these practices depends on teachers' capacity to interpret student thinking and adapt instruction responsively—core dimensions of PCK. Subsequent syntheses have reinforced this conclusion, emphasizing that instructional effectiveness for students with mathematics LD depends not only on which strategies are used, but on how and when teachers deploy them in response to students' understanding (Dennis et al., 2016; Gersten et al., 2022). Misri et al. (2025) similarly reported that students demonstrated stronger learning outcomes when instruction was delivered by teachers with well-developed PCK who could implement evidence-based strategies—such as the CRA sequence—with conceptual clarity and flexibility.

Collectively, these findings indicate that while direct research on PCK in LD-specific contexts remains limited, the convergence of intervention studies, meta-analyses, and systematic reviews consistently points to PCK as a critical mechanism for effective mathematics instruction for students with LD, enabling teachers to translate evidence-based strategies into meaningful, conceptually coherent learning experiences.

4.2. Professional Development Studies Targeting Mathematics Teachers' PCK

Experimental and quasi-experimental studies indicate that strengthening teachers' PCK in mathematics through targeted PD can improve instructional practice and, in some

cases, student achievement. Lynch et al. (2025) report that PD targeting teachers' PCK is associated with improvements in instructional practices, such as richer use of representations, more effective questioning, and increased attention to student thinking, which in turn are linked to modest but meaningful gains in elementary students' mathematics performance.

More directly relevant to students with LD, the Prime Online project (Griffin et al., 2018), a randomized controlled trial funded by the Institute of Education Sciences, examined the effects of a PD model designed to strengthen teachers' mathematics PCK in inclusive elementary classrooms. The intervention emphasized diagnostic assessment, conceptual explanations, and instructional decision-making for students with disabilities. Results indicated significant improvements in teachers' pedagogical reasoning and instructional responsiveness, with downstream effects on student engagement and conceptual understanding varying as a function of implementation fidelity. These findings suggest that PCK-focused professional learning holds promise for improving mathematics instruction for students with LD, particularly when PD is sustained and includes opportunities for practice and coaching.

Additional syntheses underscore the need for continued PD targeting teachers' understanding of students with LD in mathematics. Misri et al. (2025), in a systematic review, identified persistent gaps in teachers' preparation regarding understanding mathematical learning difficulties and implementing differentiated instruction, underscoring the importance of comprehensive training that integrates PCK with evidence-based practices. Complementing these findings, a qualitative study by Topal and Özsoy (2024) documented challenges teachers face due to limited knowledge of students with LD and insufficient instructional support, further highlighting the need for targeted PD to address these gaps.

Research on PD design also provides insight into how PCK can be effectively developed. Fukaya et al. (2024) reported that PD interventions designed to promote PCK acquisition yielded stronger effects than content-only approaches. However, these effects were more robust in science than in mathematics, suggesting a need to continue refining mathematics-focused PD models. Finally, a recent meta-analysis by Franklin and Chang (2025) that synthesized empirical studies of K–12 mathematics PD programs found that well-designed PD can significantly improve student outcomes. Collectively, this body of work reinforces the conclusion that teachers are key agents of change in students' mathematics learning and that strengthening teachers' content knowledge, pedagogical knowledge, and instructional decision-making through high-quality PD remains a critical lever for improving mathematics achievement (Ball et al., 2008; K. M. Hill & Luft, 2015; Shulman, 1986).

4.3. Key PCK Components Supporting Conceptual Understanding for Students with LD

Empirical research and syntheses consistently identify several components of teachers' PCK as particularly consequential for fostering conceptual understanding among young students with LD. First, knowledge of common misconceptions—such as misunderstandings of the equal sign, place-value reversals, or additive reasoning in multiplicative contexts (Booth et al., 2017; L. S. Fuchs et al., 2008)—enables teachers to respond productively to errors rather than relying solely on procedural reteaching. Second, purposeful use of multiple representations, including concrete manipulatives, visual models, and symbolic notation, reduces cognitive load and strengthens conceptual connections (Bouck et al., 2017; Gersten et al., 2009). Third, expertise in explicit instructional strategies—such as modeling through think-alouds, worked examples, and gradually fading scaffolds—makes mathematical reasoning visible and supports transfer (Archer & Hughes, 2011; Swanson et al., 2008; Xin et al., 2023). Finally, formative assessment and progress monitoring allow

teachers to make data-informed instructional adjustments, a practice strongly associated with improved outcomes for students with disabilities (D. Fuchs & Fuchs, 2006).

The effectiveness of these PCK components depends not only on their presence but also on teachers' ability to integrate them coherently in classroom instruction. Meta-analyses, PD evaluations, and intervention research indicate that instructional effectiveness for students with LD hinges on teachers' capacity to enact evidence-based strategies thoughtfully and responsively. Teachers with strong PCK can distinguish between procedural errors and conceptual misunderstandings, adapt representations to learners' needs, scaffold learning for transfer, and align assessment with instruction, thereby translating empirical knowledge into meaningful, conceptually rich classroom practice. Collectively, these findings also suggest that strengthening PCK is a foundational lever for supporting inclusive mathematics instruction that promotes deeper, more durable conceptual learning for students with LD.

5. From Empirical Evidence to Classroom Enactment

5.1. Bridging PCK and Practice

The empirical literature reviewed in Section 4 underscores that teachers' PCK is a pivotal determinant of effective mathematics instruction for young students with LD. Meta-analyses, PD studies, and intervention research converge on a common conclusion: evidence-based instructional practices yield the greatest impact when teachers can interpret student thinking, anticipate misconceptions, and make informed, moment-to-moment instructional decisions grounded in strong PCK (Ball et al., 2008; Depaeppe et al., 2013; Gersten et al., 2009).

However, research findings alone do not fully capture how PCK is enacted in the complexity of everyday classrooms. Teachers must translate theoretical principles, such as the use of multiple representations, structured error analysis, and formative assessment, into responsive instructional moves that address students' immediate conceptual needs. This translation process is particularly critical for students with LD, whose learning trajectories often require adaptive scaffolding, strategic pacing, and deliberate connections across representations to support conceptual coherence and transfer (D. Fuchs et al., 2014).

To illuminate this process, the following section shifts from empirical synthesis to practice-based illustration. Section 5.2. presents classroom-based interventions and instructional vignettes that demonstrate how teachers draw upon PCK to diagnose misconceptions, select and sequence instructional representations, and scaffold conceptual understanding for students with LD in inclusive and specialized settings. These vignettes are not intended as prescriptive models but as illustrative examples of how PCK functions as a dynamic, integrative resource guiding instructional decision-making in real time. By grounding research-based principles in real-world classroom contexts, the vignettes make visible the instructional reasoning that connects theory, evidence, and practice.

5.2. Instructional Vignettes and Classroom Applications

The teaching examples presented in the vignettes were intentionally selected to illustrate the practical application of the three core components of PCK in mathematics instruction for students with LD. Each example focuses on a specific aspect of PCK: content knowledge, knowledge of student thinking and errors, or knowledge of instructional strategies. They illustrate how teachers can support students' conceptual understanding rather than merely procedural competence.

These examples also reflect common classroom scenarios and challenges faced by elementary teachers, providing concrete, actionable illustrations that bridge theory and practice. Both empirical findings and practice-based considerations guided the selection to ensure relevance and classroom feasibility. Each vignette is organized using a consis-

tent analytic structure to highlight instructional context, PCK components, instructional decisions, conceptual payoff, and key insights.

5.2.1. Vignette 1: Building Number Sense with Multiple Representations

Instructional Context

- Grade: 3rd grade, inclusive classroom.
- Content focus: Place value and two-digit number reading.
- Learning goal: Students will understand the value of digits in two-digit numbers and avoid digit-reversal errors (e.g., reading “43” as “34”).

PCK Component Illustrated

- Content knowledge: Place value concepts.
- Knowledge of student thinking/misconceptions: Digit reversals, misunderstanding of tens and ones.
- Instructional strategies: CRA sequence, guided questioning, small-group modeling.

Instructional Decision and Rationale

Ms. Rivera observed persistent digit-reversal errors among a few students with LD and hypothesized that they lacked a foundational understanding of place-value. She implemented a three-stage CRA sequence using base-ten blocks (concrete), pictorial representations (representational), and symbolic notation (abstract) to make the numerical structure visible (Witzel et al., 2003). Guiding questions such as “What do the rods show?” and “What would happen if we had more ones than tens?” prompted students to articulate their reasoning, link manipulatives to symbolic notation, and address misconceptions directly (see Figure 2 for example). She also incorporated number lines and open number sentences to reinforce conceptual connections.

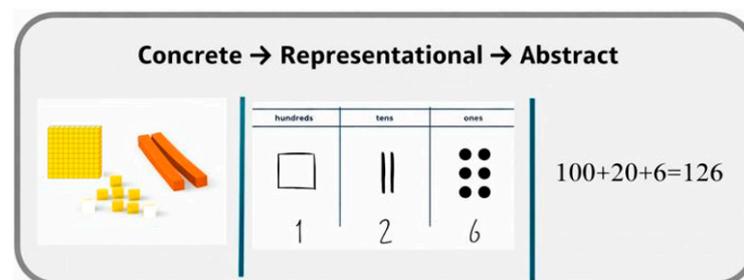


Figure 2. CRA Sequence.

Conceptual Payoff for Students with LD

By engaging with multiple representations, students could internalize the structure of two-digit numbers. It further reduces cognitive load and prevents reversal errors. Jordan, a student with LD, connected tens and ones concretely: “Four tens mean forty, plus three ones make forty-three, not thirty-four!” Post-assessment showed an increase in place-value accuracy from 45% to 90% within two weeks, demonstrating improved conceptual understanding and confidence. After the lesson, Ms. Rivera reflected, “Using multiple representations helped students see the structure of numbers, not just memorize them. That shifted students’ confidence and accuracy.”

Key Insights

This vignette illustrates how integrating all three components of PCK supports students with LD’s conceptual understanding of place value. Ms. Rivera’s strong PCK enabled her to identify digit-reversal errors as indicators of fragile place-value understanding rather

than careless mistakes. By anticipating this misconception, she strategically employed a CRA sequence and guided questioning to make the base-ten structure explicit. For students with LD, the use of multiple representations reduced cognitive load and supported the coordination of concrete, pictorial, and symbolic knowledge, resulting in durable conceptual understanding and transfer to symbolic tasks.

5.2.2. Vignette 2: Unpacking the Equal Sign Through Error Analysis

Instructional Context

- Grade: Upper elementary, resource-room setting.
- Content focus: Relational understanding of the equal sign.
- Learning goal: Students will interpret the equal sign as indicating equivalence between expressions, rather than as a signal to compute a result.

PCK Component Illustrated

- Knowledge of student thinking/misconceptions: Misinterpretation of the equal sign as a “do something” symbol.
- Instructional strategies: Error analysis, balance-scale modeling, guided discussion.

Instructional Decision and Rationale

In Mr. Chen’s resource-room setting, students with LD consistently struggled to solve equations such as $3 + 4 = \underline{\quad} + 2$, often responding with “7” without attending to the equation’s structure. Drawing on his knowledge of common misconceptions, Mr. Chen intentionally designed a guided discussion centered on error analysis to surface and confront students’ interpretations of the equal sign as a signal to compute rather than a symbol of equivalence (McNeil & Alibali, 2005).

He began by presenting two student-generated solutions—one correct and one incorrect—and invited students to discuss which response they agreed with and why. Rather than immediately evaluating answers, Mr. Chen prompted students with open-ended questions such as, “What does the equal sign tell us to do?”, “How do we know both sides are the same?”, and “What happens if we only look at one side of the equation?” These prompts encouraged students to verbalize their reasoning, compare strategies, and attend to the relational structure of the equation.

To anchor the discussion conceptually, Mr. Chen introduced a balance-scale model, physically representing each side of the equation and asking students to predict what would happen if additional values were added to only one side (see Figure 3 for example). As students discussed their predictions, he guided them to notice the imbalance and revise their reasoning. This dialogic process allowed misconceptions to be addressed collectively, providing immediate opportunities for clarification and scaffolding before students transitioned to independent, increasingly complex equation-solving tasks.

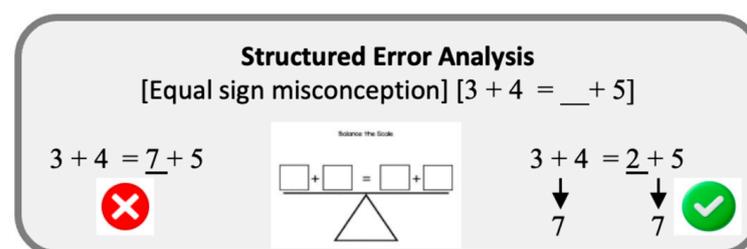


Figure 3. Error Analysis.

Conceptual Payoff for Students with LD

Students articulated reasoning about equivalence and began self-correcting errors. Lila, for example, recognized that “This answer only used the left side. The equal sign means both sides are the same” and subsequently solved non-routine equations correctly. This approach clarified the relational meaning of the equal sign, strengthened conceptual understanding, and increased students’ confidence in applying the principle across new problems. Mr. Chen reflected, “Seeing students articulate their reasoning shifted my approach; I now anticipate this misconception and pre-teach the relational meaning of ‘=’ before tackling equations.

Key Insights

This vignette highlights the central role of teachers’ knowledge of student thinking in addressing persistent misconceptions about the equal sign. Mr. Chen’s use of error analysis and balance-scale representations reflects PCK-informed instructional decision-making that foregrounds conceptual meaning over procedural execution. By engaging students with LD in identifying and explaining errors, instruction shifted from answer-getting to relational reasoning. This approach not only clarified the mathematical meaning of equivalence but also supported metacognitive awareness, enabling students to self-monitor and generalize their understanding to non-routine equations.

5.2.3. Vignette 3: Building Multiplicative Reasoning Through an Explicit Instruction Approach

Instructional Context

- Grade: 4th grade, inclusive classroom.
- Content focus: Multiplication and understanding equal groups.
- Learning goal: Students will develop multiplicative reasoning, shifting from additive strategies to conceptualizing multiplication as combining equal groups.

PCK Component Illustrated

- Content knowledge: Multiplication concepts, equal groups.
- Knowledge of student thinking/misconceptions: Tendency to apply additive reasoning (e.g., 5×3 as $5 + 3$).
- Instructional strategies: Think-aloud modeling, guided practice, Number Talks, multiple practice opportunities (IR flashcards), scaffolding, distributed practice.

Instructional Decision and Rationale

Ms. Patel observed that Marcus, a student with LD, solved 5×3 using addition. Drawing on her PCK, she began an explicit instruction sequence with think-aloud modeling, demonstrating how to conceptualize multiplication as equal groups and verbalizing her reasoning as she solved 4×3 . She invited students to follow along, making her thought process visible, then transitioned to guided practice. During this phase, she prompted students to explain their reasoning aloud through Number Talks and encouraged them to illustrate problems with dots or arrays. When Marcus initially suggested “7,” she prompted him to illustrate his thinking: “Can you draw how you saw the problem?” Marcus sketched four groups of three dots and exclaimed, “Oh—I see now! Four groups of three is twelve,” prompting him to self-correct his reasoning.

To reinforce learning, Ms. Patel provided multiple opportunities to practice multiplication facts using IR flashcards, then gradually faded support so students could practice independently. She also planned distributed practice sessions over subsequent days to strengthen retention and conceptual fluency. Throughout, scaffolding was adjusted based

on students' responses, ensuring that each learner could connect concrete representations to abstract multiplication concepts.

Conceptual Payoff for Students with LD

By combining think-aloud modeling, guided practice, visual representation, and scaffolded independent practice, students like Marcus developed a deeper understanding of multiplication as equal groups rather than additive reasoning. These strategies made the reasoning visible to the students, supported conceptual connections, and promoted generalization of multiplicative strategies. Marcus's accuracy improved from 50% to 85% within one week, and he began articulating multiplicative reasoning fluently. Ms. Patel reflected that the sequence allowed her to diagnose misconceptions in real time, target conceptual shifts efficiently, and scaffold students toward independent, confident application of multiplication strategies.

Key Insights

This vignette demonstrates how PCK enables teachers to diagnose and remediate conceptual barriers in students' understanding of multiplication. Ms. Patel recognized Marcus's reliance on additive reasoning as a conceptual obstacle rather than a computational deficit and responded with explicit instruction, think-aloud modeling, and scaffolded practice. By making the structure of equal groups visible through representations and discourse, she supported students with LD in transitioning from additive to multiplicative reasoning. The coordinated use of modeling, guided practice, and distributed rehearsal reduced cognitive overload and promoted conceptual fluency and generalization.

6. Teacher Development and Support for Strengthening PCK

Building teachers' PCK requires sustained professional learning that combines collaboration, reflection, and data-driven analysis. A growing body of empirical research demonstrates that targeted PD in PCK can lead to measurable changes in teachers' instructional practices and corresponding improvements in students' mathematical understanding (e.g., [Fukaya et al., 2024](#); [Griffin et al., 2018](#); [Misri et al., 2025](#)).

6.1. Professional Learning Models Supporting PCK Growth

Collaborative professional learning communities (PLCs) and lesson-focused team planning have been examined in multiple case studies and design-based investigations. For example, [Kazemi and Hubbard \(2008\)](#) documented how sustained collaborative analysis of student work within grade-level teams functioned as a form of teaching experiment, prompting teachers to refine their interpretations of student misconceptions and adopt more targeted questioning strategies. These instructional shifts were associated with improved student explanations and increased use of mathematically precise language. Similarly, the synthesis of case studies on PLCs by [Vescio et al. \(2008\)](#) found consistent evidence that collaborative planning and reflective dialog strengthened teachers' content-specific instructional decisions and contributed to gains in student achievement.

Video-based PD has also been shown to support PCK growth through teaching experiments and longitudinal case studies. [Sherin and van Es \(2009\)](#) demonstrated that structured video reflection supported teachers' noticing of student thinking and increased the frequency and quality of responsive instructional moves, such as probing questions and representation-based explanations during Number Talks. These changes in teacher practice coincided with students producing more conceptually grounded mathematical justifications during whole-class discussions. [Tripp and Rich \(2012\)](#) similarly reported that video-based coaching interventions led to observable improvement in teachers' scaffolding practices and stronger alignment between instructional goals and enacted instruction.

Evidence from single-case design and intervention studies further supports the impact of PCK-focused PD on student outcomes. [D. Fuchs et al. \(2014\)](#) found that PD focused on progress-monitoring data and error analysis improved teachers' instructional responsiveness, leading to significant gains in students' mathematical problem-solving accuracy. More recently, [Rojo et al. \(2021\)](#) reported that sustained engagement in student work analysis reduced teachers' misconceptions about foundational concepts such as the equal sign and place value, with corresponding improvements in students' conceptual understanding and use of mathematical language.

In addition to collaborative structures, mentorship and instructional coaching have been investigated through quasi-experimental and case study designs. [Knight \(2007\)](#) found that coaching models emphasizing modeling, observation, and feedback led to increased teacher fidelity in implementing evidence-based instructional routines and strengthened their confidence in diagnosing students' conceptual gaps. Peer-led lesson study, adapted from the Japanese model, has similarly been shown to support iterative refinement of instruction and shared accountability for student learning through case-based research ([C. C. Lewis et al., 2009](#)). Collectively, these studies provide converging evidence that teacher development models explicitly focused on strengthening PCK can produce observable changes in instructional practice and support meaningful gains in students' mathematical understanding.

6.2. Practical Recommendations for Educators and Schools

Drawing on empirical literature discussed in this manuscript, several key principles emerge for strengthening educators' PCK in mathematics. First, collaborative examination of student work deepens teachers' understanding of common errors and supports the design of targeted instructional responses ([Kazemi & Hubbard, 2008](#)). Second, analyzing classroom video enables teachers to notice subtle features of student thinking and to refine their questioning and representation use ([Tripp & Rich, 2012](#)). Third, regular engagement with data from mathematics probes and progress-monitoring tools supports instructional pacing, scaffolding, and teachers' confidence in diagnosing conceptual gaps ([D. Fuchs et al., 2014](#)).

To operationalize these principles in daily practice, the following strategies are recommended:

1. **Daily Reflection Logs:** Teachers may set aside five minutes at the end of each lesson to document which representations were effective, which misconceptions emerged, and how students responded to instructional scaffolds. Brief, structured reflection supports professional learning through reflection-on-action ([Schon, 1983](#)).
2. **Mini Data Chats:** Teachers may participate in brief weekly meetings to share one focal data point (e.g., accuracy on IR flashcards or exit tickets) and collaboratively determine next instructional steps. Such focused collaboration promotes collective responsibility for instructional decision-making ([C. C. Lewis et al., 2009](#)).
3. **Lesson Planning with PCK Prompts:** Lesson plans may incorporate explicit prompts, such as: What prior knowledge will students draw on? Where might misconceptions arise? Which representations will best clarify this concept? Embedding these prompts supports anticipatory instructional planning grounded in PCK ([Ball et al., 2008](#)).
4. **Peer Coaching Cycles:** Teachers may engage in short cycles of peer observation or co-teaching focused on a single PCK component (e.g., use of visual models or questioning strategies), followed by targeted feedback. Coaching models that emphasize modeling, observation, and reflection have been shown to strengthen instructional fidelity and responsiveness ([Knight, 2007](#)).

Reflective Practice and Self-Assessment of Teachers' PCK

Reflective practice plays a critical role in the ongoing development of teachers' PCK. For instance, in case studies conducted in basic and post-basic schools in Muscat, [Juma \(2024\)](#) found that systematic teacher self-assessment and reflection supported professional growth and instructional effectiveness. Teacher testimonies further suggested that reflective practices enhanced instructional processes and contributed positively to both teachers' professional learning and students' outcomes ([Juma, 2024](#)). When educators routinely examine their teaching—considering what worked, what did not, and why—they gain insight into their instructional strengths and areas for improvement ([Minott, 2010](#)).

Engaging in reflective practice sharpens teachers' awareness of students' learning needs, improves decision-making regarding pacing, scaffolding, and representation use, and supports intentional instructional adjustments rather than reliance on trial and error ([Juma, 2024](#)). Collectively, research suggests that reflective practice is associated with heightened teacher professionalism and improved classroom outcomes ([Minott, 2010](#)).

To support systematic self-assessment of PCK, educators may use the following guiding questions:

- Content Knowledge: Which mathematical relationships do my students struggle to connect, and how effectively do I explain these connections?
- Knowledge of Student Thinking: What evidence do I gather to identify students' misconceptions, and how promptly and accurately do I respond?
- Instructional Strategies: How varied and purposeful are the representations I use, and do students receive sufficient opportunities for practice with feedback?

Completing self-assessments monthly or following major instructional units (see [Table 1](#) for a sample tool) can help teachers monitor growth, set specific instructional goals, and plan targeted PD. As suggested in [Table 1](#), teachers may rate themselves on a scale from 1 (needs improvement) to 5 (highly proficient) across core PCK components and document concrete examples or action steps to guide continued growth in support of students' conceptual understanding.

Table 1. Sample Teacher Reflection Tool: PCK Self-Assessment.

| PCK Component | Self-Rating (1–5) | Evidence/Examples | Action Steps for Improvement |
|---|-------------------|-------------------|------------------------------|
| Content Knowledge: I clearly explain mathematical relationships and connections (e.g., why multiplication is combined equal groups). | | | |
| Student Thinking: I anticipate common misconceptions (e.g., equal-sign errors) and accurately diagnose student reasoning. | | | |
| Instructional Strategies: I use multiple representations (concrete, visual, symbolic) and select scaffolds that target identified conceptual gaps. | | | |
| Questioning Techniques: I use open-ended and probing questions to elicit students' mathematical thinking. | | | |
| Feedback and Assessment: I provide timely, specific feedback and use formative probes (e.g., curriculum-based measurement fluency checks) to guide instruction. | | | |
| Differentiation and Inclusivity: I adapt tasks and grouping to meet diverse learner needs, including students with LD. | | | |
| Reflection and Collaboration: I regularly engage in video reflection, peer discussion, or PLC discussions to refine my practice. | | | |

Teachers can utilize data from self-assessments to establish professional goals, pursue targeted coaching, and monitor PCK growth over time. In addition to periodic self-ratings, teachers may engage in structured self-reflection of their scores and responses following each major instructional unit by considering the following guiding questions:

1. Which instructional move had the greatest impact on student understanding during this unit, and why?
2. What misconceptions emerged that were not anticipated, and how should future lessons be adjusted to address them more proactively?
3. Which representations were most effective, and which need refinement?
4. How did students with LD respond differently, and which supports proved most helpful?
5. Which aspect of my PCK will I prioritize next, and what resources, collaboration, or coaching will support that focus?

7. Discussions and Implications

This manuscript contributes to the mathematics education and special education literature by offering a practice-based conceptual synthesis that illustrates how teachers' PCK can be leveraged to strengthen conceptual understanding for students with LD. Addressing a documented gap in the literature, the synthesis integrates research on mathematics teachers' PCK with empirical findings from mathematics intervention and special education research, rather than relying solely on the relatively limited body of LD-specific PCK studies. In doing so, the manuscript positions PCK as a critical mechanism through which evidence-based instructional practices are enacted in inclusive mathematics classrooms (Frischemeier et al., 2025; Gersten et al., 2009; H. C. Hill et al., 2008).

The analysis clarifies how the three interrelated components of PCK—content knowledge, knowledge of student thinking and misconceptions, and instructional strategies—function dynamically to guide instructional decision-making (Ball et al., 2008; Shulman, 1986). By making these processes explicit through classroom vignettes and practitioner-oriented examples, the manuscript illustrates how elementary teachers purposefully select representations, anticipate conceptual barriers, analyze student errors, and sequence instruction to reduce cognitive load while maintaining mathematical rigor. This integrated view helps explain how PCK may support not only immediate understanding but also the development of transferable conceptual knowledge for students with LD (Geary et al., 2013; Gersten et al., 2009).

At the same time, implementing PCK-informed instruction involves important practical and logistical considerations. Developing PCK requires sustained teacher preparation time, including PD, collaborative planning, and structured opportunities for reflection (Cojorn & Sonsupap, 2024; Darling-Hammond et al., 2017; Desimone, 2009). These efforts may involve financial costs for training, instructional materials, and ongoing support, as well as organizational demands associated with PLCs or mentoring structures. Nevertheless, the instructional benefits documented in the literature, such as improved teacher decision-making, increased responsiveness to student misconceptions, and instructional practices associated with stronger conceptual understanding for students, including students with LD, underscore the value of investing in PCK-focused initiatives (Filgona et al., 2020; H. C. Hill et al., 2008; McCray & Chen, 2012).

Grounded in classroom vignettes and aligned with a coherent conceptual framework (see Figure 4), this synthesis translates research into actionable guidance for teacher preparation and PD. By situating PCK within inclusive mathematics contexts and explicitly addressing both its instructional potential and implementation constraints, the manuscript extends existing PCK scholarship. It highlights the need for strategic planning, administrative support, and scalable PD models. Collectively, this work provides a foundation for

future empirical research examining how PCK development can be sustained over time and how it contributes to meaningful learning outcomes for students with LD.

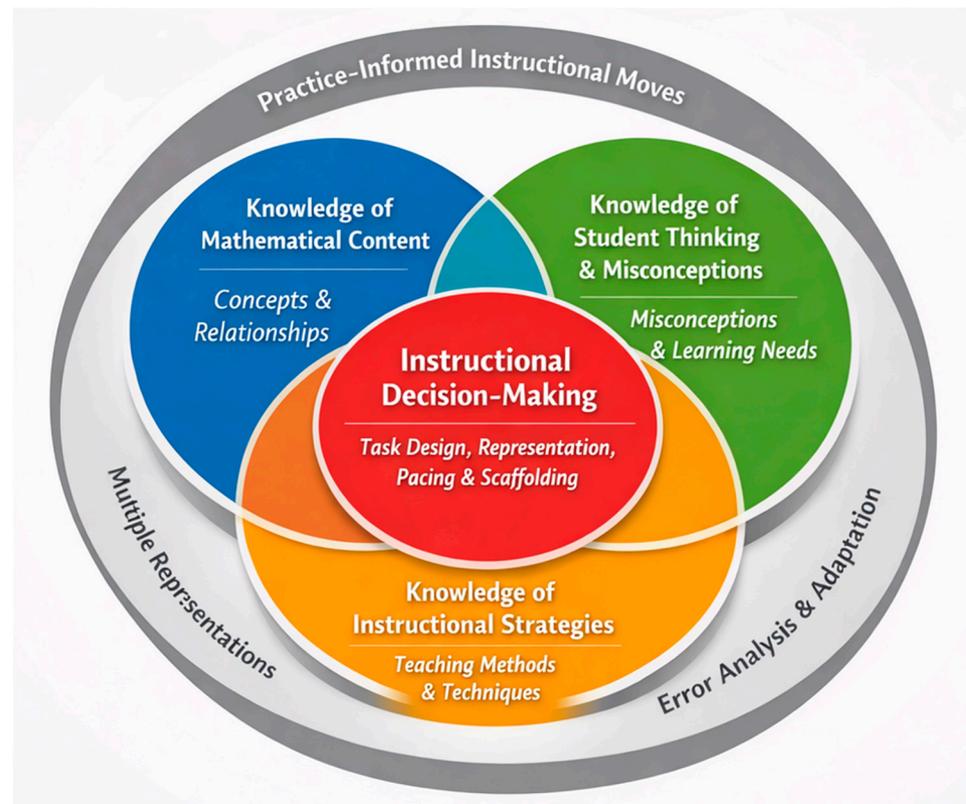


Figure 4. A Practice-Based Conceptual Framework of Mathematics Teacher's PCK.

7.1. Implications for Practice

Enhancing PCK among mathematics teachers has far-reaching implications for instructional practice, particularly for addressing the unique learning needs of students with LD in mathematics. Teachers with strong content knowledge and well-developed awareness of student thinking are better positioned to design instruction that strategically targets conceptual misunderstandings, such as place-value reversals or relational interpretations of the equal sign, through carefully sequenced representations and scaffolded learning experiences (Ball et al., 2008).

To support the systematic enactment of these practices, districts and schools can invest in the following structural supports:

- **Dedicated PD Time:** Allocating scheduled, sustained opportunities for collaborative planning, reflection, model teaching, and data analysis enables teachers to continuously refine their PCK (Cojorn & Sonsupap, 2024; Darling-Hammond et al., 2009). Embedding professional learning within the school calendar through recurring PLCs fosters accountability and collective ownership of instructional improvement.
- **Resource Accessibility:** Ensuring ready access to instructional resources, including physical and digital manipulatives, video exemplars of effective mathematics instruction, diagnostic assessment probes, and fidelity checklists, empowers teachers to implement evidence-based practices with conceptual clarity and confidence.
- **Instructional Coaching:** On-site instructional coaches or specialists can provide just-in-time feedback, co-teaching support, and personalized mentoring, reinforcing teachers' application of PCK and troubleshooting challenges in authentic classroom contexts (Knight, 2007; Motto, 2021).

- General and Special Education Collaboration: Collaboration between general and special education teachers is essential for inclusive mathematics instruction. Co-teaching models, such as station teaching and team teaching, allow educators to integrate complementary expertise, co-design differentiated tasks, and dynamically adjust supports for students with learning needs within general education settings (Friend & Cook, 2010). Additionally, joint lesson study, in which teachers collaboratively plan, observe, and refine instruction, promotes peer learning and shared problem-solving around conceptual challenges (C. C. Lewis et al., 2006; C. Lewis et al., 2019).

Finally, school and district leaders play a critical role in sustaining these efforts by embedding PCK development into evaluation and support frameworks and recognizing exemplary instructional practice. By prioritizing PCK as a core dimension of instructional quality, schools can cultivate environments in which all students, including those with LD, experience coherent, accessible, and rigorous mathematics learning.

7.2. Implications for Future Research

While this manuscript presents a conceptual synthesis and practice-based guidance, additional empirical research is needed to evaluate how PCK is enacted in special education and inclusive mathematics classrooms and how PCK-informed instructional strategies influence students' conceptual understanding, particularly for students with LD. Future studies should prioritize disability-specific investigations using randomized, quasi-experimental, longitudinal, or design-based methodologies, as well as action research approaches, to capture both instructional processes and learning outcomes over time.

Practice-based measures, such as video analysis of instructional decision-making, representation use, and teachers' responsiveness to student misconceptions, may clarify how PCK operates in real-time classroom contexts. Collectively, this line of research would provide critical evidence regarding the sustainability of PCK development, its impact on conceptually focused assessments and mathematical reasoning, and the practical feasibility and effectiveness of PCK-based approaches across diverse educational settings.

7.3. Limitations

Although substantial evidence supports the importance of PCK in mathematics instruction, much of the existing research focuses on general student populations rather than students with formally identified LD, limiting direct applicability to inclusive and special education contexts. Furthermore, relatively few studies employ mediation or process-oriented analyses to determine whether improvements in teachers' PCK directly account for gains in students' conceptual understanding (Depaepe et al., 2013; H. C. Hill et al., 2008). Additionally, practical and logistical constraints, such as limited time for sustained PD, variability in coaching availability, curricular pacing demands, and inconsistencies in assessment practices, may further complicate the implementation and evaluation of PCK-based approaches across school settings.

We also acknowledge that the instructional vignettes presented are not empirical models; instead, they serve as illustrative examples intended to bridge theory and practice by making instructional decision-making visible. Finally, this manuscript represents a practice-based conceptual synthesis rather than a systematic review and therefore does not include systematic literature coverage or meta-analytic procedures.

8. Conclusions

This manuscript advances understanding of how PCK functions as a critical instructional mechanism for supporting conceptual understanding in mathematics among students with LD. Rather than positioning PCK as a static or abstract teacher attribute, this

synthesis conceptualizes PCK as an active, practice-embedded form of professional knowledge that shapes how teachers interpret student thinking, anticipate misconceptions, and enact evidence-based instructional strategies within inclusive classrooms. Situating PCK within inclusive mathematics contexts contributes to the existing scholarship. It offers actionable guidance for teacher learning, PD, and classroom practice by providing a framework that translates research-based principles into actionable instructional guidance.

To realize the promise of conceptually rich mathematics instruction, teacher preparation programs, schools, and districts must invest in the ongoing development and maintenance of PCK, addressing both the “what” and the “how” of teaching. Sustained PD, collaborative planning, instructional coaching, and integrated general- and special-education partnerships are critical levers for systemic change (Cojorn & Sonsupap, 2024; Darling-Hammond et al., 2009, 2017; Knight, 2007; C. Lewis et al., 2019). Such investments ensure that all students, including those with LD, benefit from conceptually rich mathematics instruction guided by teachers equipped to foster deep understanding and long-term mathematical success.

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Abbreviations

The following abbreviations are used in this manuscript:

| | |
|-----|------------------------------------|
| CRA | Concrete–representational–abstract |
| IR | Incremental rehearsal |
| LD | Learning disabilities |
| PCK | Pedagogical content knowledge |
| PD | Professional Development |
| PLC | Professional learning communities |

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