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Developing Prospective Teachers' Methodological Competency-Based Cognitive Level By Ensuring Cross-Topic Coherence In The Process Of Teaching Mathematics In Primary Education

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ABSTRACT

Primary mathematics learning becomes durable when pupils recognize how ideas connect across topics such as number, measurement, geometry, and early algebra. However, in many classrooms and in teacher preparation, mathematical content is still taught as a sequence of isolated units, which encourages short-term procedures rather than conceptual structures. This article argues that cross-topic coherence—the deliberate alignment of concepts, representations, tasks, and assessments across themes—can serve as a powerful mechanism for developing prospective teachers' methodological competence at a competency-based cognitive level. Using a design-based methodological approach, the study synthesizes research on pedagogical content knowledge, mathematical knowledge for teaching, and curriculum coherence to construct a practical framework for teacher education. The proposed framework operationalizes coherence through curriculum mapping, "concept bridges" between topics, representational consistency, and coherence-oriented formative assessment. Results are presented as a structured model describing how coherence work (planning, teaching moves, diagnostic assessment, and reflection) supports prospective teachers in moving from reproductive lesson planning toward analytic and design-oriented instructional decision-making. The discussion explains why coherence is not an "extra" but a core methodological competence that strengthens conceptual understanding, cognitive demand, and students' mathematical proficiency. Implications are offered for coursework, microteaching, and practicum supervision in primary teacher education.

Keywords: Primary mathematics education, cross-topic coherence, curriculum coherence, methodological competence, mathematical knowledge for teaching, pedagogical content knowledge, learning trajectories, teacher education.

INTRODUCTION

Competency-based reforms in teacher education increasingly emphasize not only what prospective teachers know, but how they use knowledge to design learning, diagnose misconceptions, choose representations, and justify instructional decisions. In primary mathematics, these methodological demands are especially high because foundational ideas develop along long trajectories: place value evolves into multi-digit operations; measurement draws on number and proportional reasoning; geometry depends on spatial structuring and language; and early algebra emerges from pattern, equality, and generalization. When these ideas are taught separately, pupils often perform procedures without understanding why they work, and teachers interpret success as "correct answers" rather than connected reasoning.

Cross-topic coherence addresses this problem by treating the curriculum as an organized system of connected concepts rather than a list of themes. Coherence is widely discussed in relation to curriculum quality and student achievement, especially in analyses contrasting fragmented topic coverage with coherent progressions that revisit big ideas with increasing depth. At the classroom level, coherence is visible when a teacher intentionally links a new topic to prior structures, maintains consistent representations, and uses tasks that require students to connect ideas rather than repeat a single template.

For prospective teachers, learning to teach coherently is a methodological competence with a strong cognitive component. It requires them to analyze the structure of content, anticipate how pupils build meaning, and orchestrate learning so that each lesson is not only "about today's topic" but also contributes to a broader trajectory. This aligns with foundational views of teaching expertise in which professional knowledge includes both understanding subject matter and understanding how learners can come to know it. It also aligns with scholarship on mathematical knowledge for teaching, which emphasizes the specialized mathematical reasoning teachers use when selecting examples, interpreting errors, and explaining ideas.

This article develops a coherence-centered framework that can be embedded in teacher education to strengthen prospective teachers' methodological competency-based cognitive level. The goal is not merely to recommend "make connections," but to specify what coherence work looks like in planning, instruction, assessment, and reflection, and how it can be taught systematically in primary teacher preparation.

This article uses a design-based methodological strategy combining theoretical synthesis and framework construction. First, a structured analysis of foundational research and policy literature on teacher knowledge (pedagogical content knowledge and mathematical knowledge for teaching), conceptual understanding, learning trajectories, and curriculum coherence was conducted to identify mechanisms by which coherence supports learning and teaching. Second, the analysis was translated into a practical framework intended for use in pre-service coursework, microteaching, and practicum supervision. Third, coherence indicators were operationalized as observable methodological actions and products, including curriculum maps, lesson rationales, diagnostic questions, and reflective commentaries that explicitly trace links across topics.

Because the study's purpose is methodological development rather than statistical generalization, evidence claims are presented as design results: a model specifying components, relationships, and implementation routines. The approach is consistent with teacher-education research traditions that treat well-justified instructional frameworks as research outputs when they integrate theory, respond to practice-based constraints, and include explicit operational definitions that can be tested in future empirical studies.

The main result is a framework that defines cross-topic coherence as a teacher's capacity to maintain conceptual, representational, and assessment continuity across themes while preserving cognitive demand. This capacity is expressed through four interdependent domains of methodological competence.

Prospective teachers develop coherence by learning to represent the curriculum as a network of big ideas and dependencies. For example, "unitizing" links counting, place value, measurement units, area structuring, and fraction meaning; "equivalence" links equality, comparison, fraction equivalence, and balance representations; "composition and decomposition" links number bonds, shape partitioning, and algorithmic regrouping. The mapping task shifts lesson preparation from choosing activities to articulating the mathematical purpose and its position in a progression. This idea resonates with learning trajectory work, which treats learning as movement along conceptually meaningful paths rather than jumps between disconnected skills.

Coherence becomes instructionally real when prospective teachers design short, explicit bridges between topics. A bridge is not a decorative "connection," but a planned reasoning move. For instance, when introducing perimeter, a teacher can bridge to addition and place value by asking students to compose lengths using standard units, record sums, and compare strategies; when introducing area arrays, a teacher can bridge to multiplication meaning by structuring rows and columns and linking repeated addition to groups. The methodological competence here includes selecting bridge tasks that are mathematically faithful and developmentally appropriate, and scripting questions that elicit connections rather than only answers.

Many primary misconceptions emerge because representations change without explanation. A coherence-oriented teacher uses consistent representational families (number line, ten-frame, base-ten blocks, arrays, bar models, diagrams for measures) and teaches how one representation transforms into another. This competence involves disciplined variation: keeping the underlying structure constant while varying surface features to reveal invariants. In teacher education, prospective teachers can be trained to justify each representation by stating what structure it makes visible and what misconceptions it can surface. The focus on "understanding as connected knowledge" is consistent with classic accounts of mathematical understanding that define it through the richness of relationships among ideas.

If assessments only test isolated procedures, prospective teachers will plan in isolated procedures. The framework therefore defines diagnostic assessment as a coherence tool: teachers ask questions that require transfer across topics, such as linking fraction size to number line placement, or linking multiplication to area, or linking regrouping to decomposition. This aligns with broader conceptions of mathematical proficiency as including conceptual understanding and adaptive reasoning, not only procedural fluency. The framework recommends that prospective teachers practice writing short "coherence probes," each tied to a conceptual bridge and accompanied by anticipated student responses and follow-up prompts.

Within this framework, the "competency-based cognitive level" of a prospective teacher is expressed as the ability to (a) analyze content structure, (b) select and justify methodological tools, (c) diagnose and respond to student thinking, and (d) reflect using evidence. The framework supports movement from a reproductive level (copying lesson formats and applying generic methods) toward an analytic-design level (reasoning about why a method fits a concept, anticipating difficulties, and planning for connection-making).

The key mechanism is that coherence tasks require explanation and justification. When a prospective teacher must show how perimeter depends on additive composition and unit iteration, or how equivalence governs both numeric and geometric contexts, they are compelled to use deeper content reasoning. This mirrors the notion that effective teaching depends on forms of content knowledge that are specifically adapted to instructional practice.

Cross-topic coherence is sometimes misunderstood as a motivational "add-on" ("make lessons interesting by connecting topics"). The framework presented here treats coherence as methodological infrastructure. It influences what teachers notice, how they interpret errors, how they choose examples, and how they design tasks. In this sense, coherence is aligned with pedagogical content knowledge as a core professional capacity: a teacher does not merely know mathematics and pedagogy separately, but knows how to transform mathematics for learner understanding.

Coherence also addresses a persistent challenge in primary teacher education: the mismatch between how mathematics is structured in curricula and how it is often internalized by prospective teachers. Many prospective teachers enter preparation with procedural experiences, so they plan lessons that mirror how they were taught. Coherence work interrupts this cycle by demanding explicit reasoning about the "why" behind sequence and representation. The spiral idea—that foundational concepts can be revisited with increasing sophistication—supports this developmental view of learning and curriculum design.

Coherence, cognitive demand, and equity

A coherence approach can help preserve cognitive demand because connections typically require explanation, comparison, and justification. When students must relate a number line model to fraction equivalence or relate an array to multiplication meaning, they engage in reasoning rather than only execution. Coherence is therefore compatible with practice frameworks that emphasize robust understanding and formative assessment as central to powerful mathematics instruction. At the same time, coherence supports equity because consistent representations and explicit bridges reduce hidden prerequisites: students who missed one procedural lesson can still access ideas through connected structures and multiple entry points.

Embedding this framework into teacher education suggests three practical shifts. First, coursework should require curriculum mapping and conceptual dependency analysis as regular assignments, not occasional projects. Second, microteaching should be evaluated not only on classroom management and activity flow but on whether the prospective teacher establishes and sustains conceptual bridges. Third, practicum supervision should include coherence-focused observation tools, with mentors prompting prospective teachers to explain how a lesson contributes to a broader progression and how assessment evidence will inform subsequent bridging.

Developing prospective teachers' methodological competence in primary mathematics requires more than training in techniques; it requires building the cognitive capacity to see mathematics as a coherent system and to teach it as such. Cross-topic coherence provides a practical, theoretically grounded pathway for this development because it integrates content analysis, representation management, task design, and diagnostic assessment into a single methodological competence. The framework proposed in this article operationalizes coherence in ways that can be taught, practiced, and observed in teacher preparation. Future empirical studies can test its effects on prospective teachers' planning quality, instructional decision-making, and students' conceptual learning outcomes, but the present contribution is a detailed model that makes coherence a concrete target of competency-based teacher education.

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