Proceedings of International Conference on Research in Education (ICRE) 2025, pp. 293-299
ISSN: 3124-4467
27-28 November 2025 - Yogyakarta, Indonesia
https://e-conf.usd.ac.id/index.php/icre
Fakultas Keguruan dan Ilmu Pendidikan, Universitas Sanata Dharma, Yogyakarta

DESIGNING A HUMAN-CENTERED FRAMEWORK FOR PRESERVICE MATHEMATICS PRIMARY SCHOOL TEACHERS: INTEGRATING COMPUTATIONAL THINKING, REFLECTIVE PEDAGOGY, AND ETHNOMATHEMATICS

Christiyanti Aprinastuti
University of Debrecen, Hungary
christiyantia@science.unideb.hu
Received: 31 October 2025; Accepted: 28 November 2025

Abstract
This paper develops a human-centred curriculum framework for preservice primary school teachers that integrates computational thinking, reflective pedagogy, and ethnomathematics. Applying a Conceptual Systematic Review (CSR) approach, the study synthesises conceptual and empirical literature from 2010 to 2025 to clarify each domain and map intersections relevant to teacher preparation. The framework positions computational thinking as a pedagogical tool for structured problem solving, reflective pedagogy as the ethical and metacognitive anchor, and ethnomathematics as the cultural and ecological grounding. Anticipated outcomes include enhanced teacher readiness for technology-rich classrooms, strengthened culturally responsive practice, and improved capacity for ethical decision-making. The paper concludes with implications for course design, program assessment, and future empirical validation.

Keywords: computational thinking, ethnomathematics, human-centred curriculum, preservice teacher education, reflective pedagogy

Introduction

The digital era demands that mathematics teachers develop comprehensive competencies beyond traditional content knowledge. In the evolution of mathematics education, preservice teacher preparation must respond to increasing demands for digital competence, reflective awareness, and cultural sensitivity. The 21st century has profoundly reshaped mathematics education through globalization, technological innovation, and cultural diversity. Teachers today must navigate not only mathematical content but also ethical, reflective, and cultural complexities (Angeli et al., 2016; Noddings, 2007). Consequently, teacher education must evolve from procedural instruction to human-centred, critical, and creative pedagogies that balance cognition with empathy (Korthagen & Vasalos, 2005; Skovsmose, 2011).

The 21st century has profoundly reshaped mathematics education through globalization, technological innovation, and cultural diversity. Teachers today must navigate not only mathematical content but also ethical, reflective, and cultural complexities (Angeli et al., 2016; Noddings, 2007). Consequently, teacher education must evolve from procedural instruction to human-centered, critical, and creative pedagogies that balance cognition with empathy (Korthagen & Vasalos, 2005; Skovsmose, 2011).

A human-centred mathematics curriculum prioritizes meaning, identity, and social responsibility in teaching (Freire, 1996; Noddings, 2007). It frames mathematics not merely as abstract reasoning but as a human activity rooted in culture, ethics, and collaboration (Boaler, 2016; Rosa & Orey, 2011). Within this view, computational thinking (CT), reflective pedagogy (RP), and ethnomathematics (EM) offer complementary pathways for empowering preservice teachers as reflective, culturally responsive, and technologically competent educators.

Recent research emphasizes that integrating CT fosters deeper problem-solving and modelling skills (Grover & Pea, 2023; Weintrop et al., 2016). Reflective pedagogy enables preservice teachers to examine their beliefs, practices, and classroom ethics (Larrivee, 2000; Schön, 1983), while ethnomathematics situates mathematics in cultural contexts, enhancing inclusion and equity (D'Ambrosio, 2006; Rosa & Orey, 2011). The convergence of these domains supports UNESCO's (2021) vision for "education that empowers learners to shape peaceful, sustainable, and just futures."

Despite these advancements, integration of CT, RP, and EM in mathematics teacher education remains fragmented. CT is often isolated as a technical skill detached from culture or ethics (Sengupta et al., 2018; Wing, 2017). RP is practised as personal reflection but lacks connection to digital pedagogy (Dewey, 2006; Schön, 1983). EM highlights cultural relevance yet rarely intersects with computational or reflective learning (Vithal & Skovsmose, 1997). This fragmentation limits preservice teachers' ability to design lessons that are logically sound, ethically informed, and culturally meaningful.

To address these gaps, this study explicitly advances beyond adjacent frameworks such as TPACK, TPACK-CT, and critical mathematics education by integrating cognitive (CT), ethical-reflective (RP), and cultural (EM) dimensions into one unified, human-centred curriculum model. This is important because current teacher education frameworks rarely articulate how CT can be taught ethically, how reflection can be evidence-based rather than emotional, or how cultural knowledge can guide computational modelling and technological decision-making.

The purpose of this study is to design a Human-Centred Curriculum Framework (HCCF) for preservice primary mathematics teachers by synthesising the theoretical and practical intersections of CT, RP, and EM. Specifically, the objectives are to: (1) analyse conceptual and empirical literature on CT, RP, and EM in mathematics education, (2) identify intersections and complementarities among these domains, (3) develop a curriculum model integrating cognitive, ethical, and cultural dimensions, and (4) demonstrate practical applications through preservice teacher training examples. This framework provides a model for mathematics teacher education that promotes digital fluency, reflective judgment, and cultural responsiveness (Aprinastuti, 2022). It contributes to ongoing discourse on sustainable, inclusive education by aligning human-centred values with contemporary pedagogical innovation (Carney, 2022; Noddings, 2007).

Method

This study employed a Conceptual Systematic Review (CSR) method, synthesizing literature on CT, RP, and EM published between 2010 and 2025. The time range (2010–2025) was selected to capture foundational CT frameworks, the rise of reflective pedagogy in teacher education, and contemporary ethnomathematics models employed in both Global South and Global North contexts. Unlike meta-analytic approaches emphasizing statistical synthesis, CSR focuses on theoretical relationships and pedagogical implications (Larrivee, 2000). Databases searched included Scopus, ERIC, and Web of Science using terms such as computational thinking in mathematics education, reflective teaching, ethnomathematics, and preservice teacher curriculum design. Search strategies included explicit Boolean strings: (“computational thinking” AND “preservice teacher”) OR (“CT” AND “mathematics education”), (“reflective pedagogy” OR “reflective practice”) AND “teacher education,” and (“ethnomathematics” AND (“curriculum” OR “teacher preparation”)).

1) Inclusion: peer-reviewed articles, book chapters, and theoretical models addressing CT, RP, or EM in teacher education. Additional inclusion criteria required (a) relevance to preservice or initial teacher education, (b) explicit discussion of CT, RP, or EM as a conceptual or instructional construct, and (c) publication in English between 2010 and 2025.
2) Exclusion: studies unrelated to mathematics or preservice contexts. Further exclusions included K–12 student-only studies, non-education computational science papers, and ethnographic studies lacking curriculum implications.

A PRISMA-style process guided the identification and screening of studies: 1,462 records were initially retrieved across the three databases, 312 duplicates were removed, 207 titles and abstracts were screened for conceptual fit, and 112 full-text articles were retained for in-depth review.

Thematic synthesis occurred in three stages (Korthagen & Vasalos, 2005):

1) Extraction – identifying definitions, theoretical roots, and pedagogical frameworks.
2) Mapping – linking shared concepts such as reflection, abstraction, and cultural contextualization.
3) Integration – merging results into the conceptual Human-Centred Curriculum Framework (HCCF).

To ensure analytic rigor, the CSR followed six steps: (1) concept untangling, (2) heuristic identification, (3) analytical classification, (4) corpus development, (5) empirical systematization, and (6) synthesis. Quality appraisal used the AACODS tool (Authority, Accuracy, Coverage, Objectivity, Date, Significance), with only studies scoring at least 4/6 included in the final corpus. Illustrative examples from teacher preparation courses were drawn from recent integration models in Indonesia (Aprinastuti, 2022).

Findings and Discussion

CT expands mathematical reasoning through decomposition, abstraction, and algorithmic design (Weintrop et al., 2016; Wing, 2017). In preservice contexts, CT helps student teachers conceptualize problems computationally and design modelling-based lessons that enhance creativity and digital fluency (Angeli et al., 2016; Grover & Pea, 2023). When integrated with reflective strategies, CT promotes not only technical mastery but also critical awareness of technology’s ethical and social implications (Sengupta et al., 2018). In addition, CT can support data-informed decision-making, enabling preservice teachers to examine student work patterns, identify misconceptions, and justify instructional choices using evidence rather than intuition.

Reflective pedagogy anchors teacher education in ethical awareness and self-regulated learning. Dewey (Dewey, 2006) defined reflection as active, persistent inquiry, while Schön (1983) conceptualized reflection-in-action as critical responsiveness during practice. Within mathematics, RP fosters awareness of how instructional choices impact learners' engagement and identity (Korthagen & Vasalos, 2005). Reflection transforms teaching into a moral practice grounded in social justice and equity (Freire, 1970; Larrivee, 2000).

Ethnomathematics situates mathematical understanding within cultural traditions and lived experiences (D'Ambrosio, 2006; Rosa & Orey, 2016) Integrating EM into preservice education encourages teachers to explore mathematical ideas through indigenous art, local architecture, or community practices (Vithal & Skovsmose, 1997). This contextual approach nurtures inclusive classrooms where mathematics becomes a reflection of diverse human experiences (Boaler, 2016).

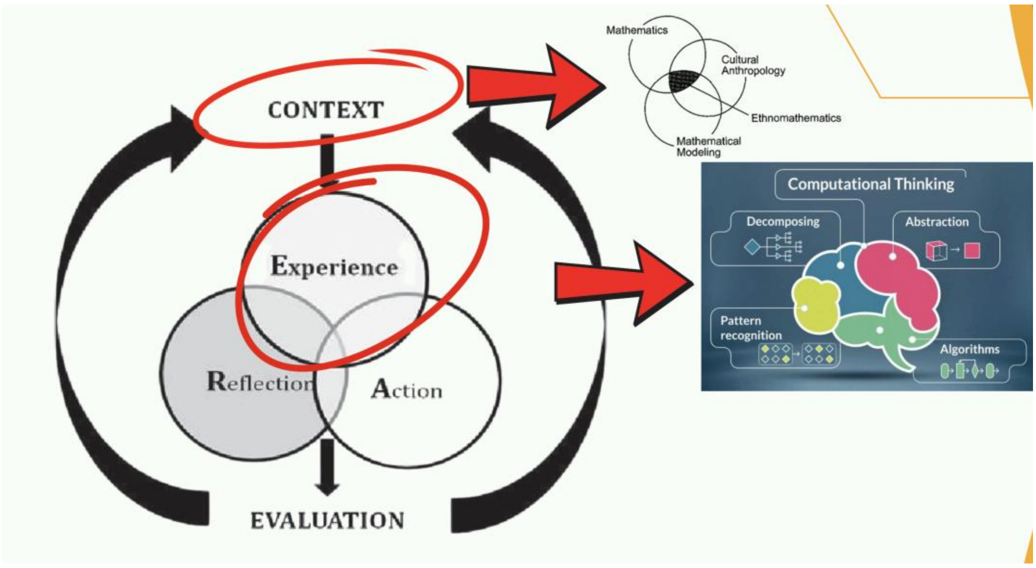

Figure 1. Contextual Approach

The synthesis reveals three key intersections. (1) Reflection ensures ethical, intentional use of digital tools for learning (Sengupta et al., 2018), by requiring preservice teachers to critically evaluate how algorithms, data, and modelling tools affect learners with diverse cultural and linguistic backgrounds. (2) Reflective practice deepens cultural awareness and challenges implicit biases in curriculum design (Larrivee, 2000), prompting teachers to interrogate whose mathematical knowledge is recognized, how culture shapes understanding, and how technological tools may privilege certain ways of thinking. (3) Computational projects grounded in local culture, such as simulating weaving or pattern generation, connect technology with heritage (Aprinastuti, 2021). For example, students can use Python, Scratch, or Blockly to model *batik* symmetries, weaving cycles, or traditional architectural ratios, allowing CT skills to support—not override—cultural authenticity.

Together, these intersections establish the Human-Centred Curriculum Framework, where cognition, reflection, and culture converge. (1) Cognitive Dimension (CT): Problem-solving and abstraction through computational modelling, (2) Ethical-Reflective Dimension (RP): Metacognitive inquiry and value-based decision-making, (3) Cultural Dimension (EM): Contextual, inclusive mathematics grounded in local knowledge.

At their intersection lies human-centred mathematics education—where preservice teachers develop empathy, agency, and cultural respect (Noddings, 2007; Skovsmose, 2011). For instance, preservice teachers designing coding projects that visualize local batik symmetries demonstrate how CT, RP, and EM foster integrated learning and cultural appreciation.

To ensure the framework is measurable, transferable, and suitable for implementation across teacher education programs, the study proposes a multi-layered evaluation plan incorporating quantitative, qualitative, and performance-based metrics. The plan assesses cognitive growth, reflective depth, cultural accuracy, and ethical considerations.

1. Pre/post assessments of CT, RP, and EM competencies. These assessments evaluate conceptual and practical understanding of each dimension. Examples include: (a) CT tasks: debugging algorithms, modelling mathematical patterns in Scratch/Python, (b) RP tasks: analysing classroom evidence and justifying pedagogical decisions. (c) EM tasks: identifying mathematical structures within local cultural practices. Example: A post-test requires modelling a batik motif using transformations and writing a reflective explanation of cultural significance.
2. Classroom performance tasks assessing integration. Preservice teachers design and teach lessons that merge CT, RP, and EM. Assessment rubrics measure: (a) CT processes (abstraction, algorithm design), (b) RP quality (evidence-linked reasoning), (c) EM authenticity (cultural respect and accuracy). Example: Teaching a Grade 4 lesson where students use Scratch to simulate rotational symmetry in a local batik pattern.
3. Fidelity-of-implementation observations during practicum. Observers examine whether preservice teachers enact the framework authentically in classroom settings. Focus areas include: (a) appropriate CT integration, (b) reflective questioning, (c) ethical representation of EM content. Example: A mentor checks whether the algorithmic sequence used to model weaving patterns reflects actual cultural processes rather than oversimplified representations.
4. Reflective journals coded using an evidence-linked rubric. The rubric evaluates: use of student evidence, connections to theory, cultural awareness, and ethical decision-making. Example: High-quality entries reference student work samples and link them to CT or EM principles.
5. Community-based feedback on EM authenticity. Local cultural practitioners validate the accuracy and respectfulness of EM tasks. Example: Batik artisans review computational models to ensure they represent motifs appropriately and respectfully.

This ensures the HCCF remains culturally grounded and ethically responsible.

Conclusion

The Human-Centred Curriculum Framework (HCCF) integrates computational thinking, reflective pedagogy, and ethnomathematics to prepare preservice primary mathematics teachers who are logical, ethical, and culturally grounded. The expanded CSR synthesis demonstrates that CT contributes cognitive tools for modelling and problem-solving, RP cultivates evidence-based professional judgment, and EM ensures curricular relevance rooted in cultural dignity and community knowledge.

A key contribution of this study is the operationalization of the HCCF into implementable curriculum elements—such as computational modelling of cultural patterns, structured reflective journals, community-informed cultural tasks, and ethics-grounded instructional decision-making—which extend existing frameworks like TPACK, TPACK-CT, and critical mathematics education. By providing a concrete evaluation plan with measurable indicators, the framework moves beyond conceptual promise toward practical program design.

The implications for teacher education include: (1) curriculum design: embed coding and digital modelling alongside reflective journaling and ethnomathematical projects. (2) teacher preparation: promote critical, culturally aware, and technologically proficient educators. (3) assessment: Use portfolios, reflective essays, and community-based mathematics projects. Future research should pilot the HCCF in diverse institutional settings, examine its impact on preservice teachers' classroom performance, and explore long-term outcomes for learners in mathematics classrooms. Sustaining the framework will require alignment with national teacher standards, UNESCO's human-centred education agenda, and robust mentoring systems during practicum placements.

References

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Educational Technology and Society*, *19*(3), 47-57. https://www.learntechlib.org/p/192695/

Aprinastuti, C. (2022). Implementation of computational thinking and Ignatian pedagogy in Geometry subject for elementary school pre-service teachers. *Jurnal Basicedu*, *6*(3), 5329–5337. https://doi.org/10.31004/basicedu.v6i3.2177

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching.* Jossey-Bass/Wiley.

Carney, S. (2022). Reimagining our futures together: a new social contract for education. *Comparative Education*, *58*(4), 568-569. https://doi.org/10.1080/03050068.2022.2102326

D'Ambrosio, U. (2006). *Ethnomathematics: Link between traditions and modernity*. Sense Publishers.

Dewey, J. (2006). *How we think.* D C Heath https://doi.org/10.1037/10903-000

Freire, P. (1996). *Pedagogy of the oppressed* (Rev. ed.). Penguin.

Grover, S., & Pea, R. (2023). Computational thinking: A competency whose time has come. In S. Sentance, E. Barendsen, N. R. Howard, & C. Schulte (Eds.), *Computer science education: Perspectives on teaching and learning in school* (pp. 51–68). Bloomsbury Academic. https://doi.org/10.5040/9781350296947.ch-005

Korthagen, F., & Vasalos, A. (2005). Levels in reflection: Core reflection as a means to enhance professional growth. *Teachers and Teaching: Theory and Practice*, *11*(1), 47-71. https://doi.org/10.1080/1354060042000337093

Larrivee, B. (2000). Transforming teaching practice: Becoming the critically reflective teacher. *Reflective Practice*, *1*(3), 293-307. https://doi.org/10.1080/713693162

Noddings, N. (2007). *Education and democracy in the 21st century*. Teachers College Press.

Rosa, M., & Orey, D. C. (2011). Ethnomathematics: the cultural aspects of mathematics. *Revista Latinoamericana de Etnomatemática*, *4(2)*, 32–54. https://revista.etnomatematica.org/index.php/RevLatEm/article/view/32

Rosa, M., Orey, D.C. (2016). State of the art in ethnomathematics. In *Current and future perspectives of ethnomathematics as a program*. ICME-13 Topical Surveys. Springer, Cham. https://doi.org/10.1007/978-3-319-30120-4_3

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Basic Books.

Sengupta, P., Dickes, A., & Farris, A. (2018). Toward a phenomenology of computational thinking in STEM education. In *Computational thinking in the STEM disciplines: Foundations and research highlights*. Springer, Cham. https://doi.org/10.1007/978-3-319-93566-9_4

Skovsmose, O. (2011). *An invitation to critical mathematics education*. Sense Publishers.

Vithal, R., & Skovsmose, O. (1997). The end of innocence: A critique of "ethnomathematics." *Educational Studies in Mathematics*, *34*, 131-157. https://doi.org/10.1023/a:1002971922833

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, *25*(1), 127-147. https://doi.org/10.1007/s10956-015-9581-5

Wing, J. M. (2017). Computational Thinking's Influence on Research and Education for All. *Italian Journal of Educational Technology*, *25*(2), 7-14. https://doi.org/10.17471/2499-4324/922