Making Student Thinking Visible in Elementary Computer Science: A Writing-Centered Professional Development Academy (Work in Progress)

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Introduction

Computer science (CS) is becoming essential in K-12 education in the United States. Foundational skills developed through CS, such as problem-solving, computational thinking, and design, are increasingly vital for modern engineering practice, particularly in developing early problem-solving and design thinking skills that are foundational to pre-college engineering education [1]. However, these thinking processes are typically invisible during learning, making them hard to assess and monitor. This invisibility creates a need for instructional approaches that capture student metacognition, or the ability to be aware of and reflect on their own thinking. The challenge is especially prevalent in elementary education, where educators may have little CS preparation and instruction can be distributed among several educators [2]. Thus, there is a pressing need for consistent, practical methods that make student thinking visible and track growth in CS skills, which is crucial as efforts to broaden STEM pathways and participation in computing expand [3].

Building on this context, in 2021, the Mississippi Computer Science and Cyber Education Equality Act was passed, requiring all school districts to offer CS instruction by the 2024-2025 school year. At the elementary level, this includes at least one hour per week of CS instruction, including keyboarding, digital citizenship, coding, and robotics. In response, the Computer Science for Mississippi (CS4MS) initiative led to the development of the Center for Cyber Education (CCE) at Mississippi State University, which provides training and professional development for K-12 educators and supports the development of a statewide CS pathway [4].

While access to CS education is growing, the main challenge is ensuring that student thinking and learning progression are made visible, especially in elementary settings where instruction spans multiple educators and contexts. Professional development typically focuses on curriculum and implementation support, but rarely addresses methods for consistently observing, assessing, and documenting how students develop computational thinking across classroom boundaries [4].

The central goal of the ***Making Student Thinking Visible in Elementary Computer Science Academy*** is to address these challenges by equipping K-5 educators with strategies to monitor and document students' computational thinking and metacognition. This two-day, asynchronous online academy introduces structured journaling, providing a practical solution to make student thinking visible, support formative assessment, and ensure instructional continuity across multiple educators involved in CS instruction.

Writing-to-learn (WTL) is an instructional approach that uses writing to support learning by encouraging students to explain their reasoning and reflect on their understanding. Research demonstrates that reflective and explanatory writing helps students clearly articulate their thinking and fosters metacognitive awareness, both of which lead to improved learning outcomes [5]. Writing in STEM contexts supports problem-solving and reflective thinking, enhancing student engagement and understanding of core engineering and CS practices. In programming education, write-to-learn-to-program (WTLTP) emphasizes reasoning and conceptual understanding rather than focusing solely on code syntax [6]. This body of work shows that structured writing clarifies students' thinking, helps educators track progress, and enables a deeper understanding of the development of computational thinking over time.

Background, Review of Related Literature, and Theoretical Framework

Writing-to-learn (WTL) theory positions writing as a cognitive activity that supports meaning-making and reflection [7]. Research in STEM education demonstrates that structured writing improves conceptual understanding and metacognitive engagement by prompting students to explain their reasoning [5], [8]. In CS, where problem-solving is not always evident from completed tasks, writing helps make computational thinking visible during learning.

WTLTP is a pedagogical approach that uses writing to support reasoning, reflection, and sense-making in programming [6]. While previous work highlights writing as a learning tool, this study extends that perspective by using writing to make student thinking visible and to document computational thinking and metacognitive development over time, especially in instructional settings with multiple educators.

Context and Design of the Academy

The *Making Student Thinking Visible in Elementary Computer Science Academy* is an asynchronous online professional development program for K-5 educators teaching CS. This two-day equivalent course introduces practical, writing-centered strategies to help make students' computational thinking and metacognition visible during instruction.

This professional development model is based on WTL and WTLTP, which support reasoning and reflection in programming. These approaches are applied through a structured *Plan, Try, Reflect, Improve* cycle, which guides students in documenting their computational thinking before, during, and after problem-solving. This cycle aligns with core engineering design practices such as problem definition, testing, and iteration, and positions writing as a tool for documenting thinking throughout the design process.

Elementary CS instruction is often shared among multiple educators and settings, which limits opportunities to consistently observe and assess student thinking. As a result, learning is often measured by task completion rather than by insight into students' reasoning, computational thinking, or metacognitive processes. To address this, the academy introduces structured journaling as a practical way to capture students' thinking and support continuity across instructional contexts.

The program includes six instructional modules and concludes with a final reflection and application component. The modules move from foundational concepts in CS and WTL theory to the practical use of writing-centered strategies in classroom practice (Table 1).

Table 1. Overview of academy modules and instructional focus

Module	Focus	Key Concepts	Writing Application
Module 1	Framing CS and Visible Thinking	Variability of elementary CS instruction; challenges in observing student thinking	Introduction to writing as a tool for making thinking visible
Module 2	Writing-to-Learn and Writing-to-Learn-to-Program	WTL Theory; computational thinking; reasoning in programming	Writing to explain problem-solving and algorithmic thinking
Module 3	Writing and Metacognition	Metacognition; reflection; iterative thinking processes	Writing to support reflection within the Plan–Try–Reflect–Improve cycle
Module 4	Writing Strategies in Elementary CS	Journaling; short responses; discussion-based writing	Practical strategies for embedding writing into CS activities
Module 5	Application of Journaling	Implementation of journal templates in CS lessons	Structured journaling before, during, and after learning
Module 6	Reflection and Collaboration	Community of Practice; instructional reflection	Sharing and refining writing-centered instructional practices

Instructional materials include journal templates, sample lesson adaptations, and planning tools designed to integrate with current instruction. Writing activities focus on concise, reflective responses that value student reasoning over accuracy.

To support implementation, the academy offers discussion activities and a community of practice. These resources help educators assess feasibility, share strategies, and collaboratively improve writing-centered approaches in elementary CS instruction.

Research Questions and Evaluation Plan

The study examines the feasibility, clarity, and instructional value of a writing-centered professional development academy designed to help elementary educators make student thinking visible in CS instruction. The academy focuses on structured writing strategies, such as journaling, to document and assess students' computational thinking and metacognitive processes. The evaluation aims to guide ongoing improvement of the Academy and contribute to the broader research agenda on writing-centered approaches in CS education.

The following research questions guide this phase of this study:

1. How do K-5 educators perceive the feasibility, clarity, and instructional value of writing-centered strategies introduced in the Academy for elementary computer science instruction?
2. How do educators engage with and make sense of writing-centered instructional practices during participation in the Academy?
3. How do educators perceive the role of writing-centered strategies in supporting the visibility of students' computational thinking and metacognition, including early considerations for classroom implementation?

The pilot cohort will include approximately 10-15 K-5 educators participating in the Academy's summer implementation. Recruitment will occur through professional networks, district partnerships, and state-level CS communication channels, targeting classroom teachers, librarians, and instructional specialists responsible for elementary CS instruction.

Data collection will begin in summer 2026 and continue into fall 2026 as educators implement writing-centered strategies. All participants will complete an end-of-course survey assessing feasibility, clarity, and instructional confidence. A subset will participate in semi-structured interviews to provide deeper insight. Participants will submit instructional artifacts developed during the Academy, including lesson adaptations and, when available, student writing samples. Classroom observations and teacher reflections will be collected from those who implement the strategies.

Quantitative survey data will be analyzed descriptively. Qualitative data from interviews, artifacts, reflections, and discussion posts will undergo inductive thematic analysis to identify patterns in educator engagement, instructional implementation, and perceptions of how writing supports the visibility of students' computational thinking and metacognitive development.

Artifacts, including lesson adaptations and student writing samples, will be examined for evidence of students' computational thinking and metacognitive processes, such as explanations of problem-solving strategies, reflections on outcomes, and iterative improvement. These findings will inform ongoing refinements to the Academy and guide future studies of classroom-level impact.

The initial phase will focus on educator perceptions and engagement. Future work will examine classroom implementation and the impact of writing-centered strategies on students' computational thinking and metacognitive development.

Discussion and Conclusion

This work-in-progress paper outlines a writing-centered professional development academy that helps elementary educators make student thinking visible during CS instruction. Drawing on research in writing-to-learn and programming pedagogy, the Academy addresses the challenge of observing and assessing students' computational thinking and problem-solving processes.

The Academy uses writing to make student thinking visible and to support computational and metacognitive development. Integrating strategies such as structured journaling into CS activities enables educators to capture students' reasoning, reflect on problem-solving, and document learning over time. This approach leverages educators' strengths in literacy and reinforces core engineering practices such as problem-solving, iteration, and design thinking, positioning writing as a tool for supporting early engagement in pre-college engineering practices.

The Academy supports educators without formal CS training who teach in diverse and distributed settings. By embedding writing into current instructional practices instead of adding new content, the Academy provides a practical and scalable way to implement elementary CS without increasing curricular demands or requiring specialized instructors.

Expected outcomes include increased teacher confidence, greater perceived feasibility of writing-centered strategies, and improved ability to observe students' computational thinking and metacognitive processes. These results support better instructional continuity and more equitable access to early CS and engineering opportunities, especially in under-resourced and distributed settings.

This initial phase examines educators' perceptions and engagement, while future research will investigate classroom implementation and the impact of writing-centered strategies on students' computational thinking and metacognition over time.

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