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Pedagogical Shift Through Computational Thinking: Reflections of Pre-Service Indonesian Language Teachers

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Abstract

Computational Thinking (CT) is one of the approaches in learning that can be used to train students in solving complex problems into simpler ones so that they can be solved more effectively. Research on the effectiveness of CT in learning has been widely conducted, but reflective research that explores the experiences of prospective language teachers has not been widely found. This study aims to reveal the reflections of prospective Indonesian language teachers when implementing the Computational Thinking (CT) approach in the learning process. This study uses a qualitative approach with a reflective-narrative study design. The data sources in this study are 19 prospective language teachers who are currently participating in education and training organized by a private university in Indonesia. Based on thematic analysis of the results of participant reflections, four main themes were found, namely (1) interesting experiences in implementing CT, (2) challenges and failures faced, (3) changes in mindset and learning strategies, and (4) improving the quality of learning. The results of the study show that although the implementation of CT presents cognitive challenges, the use of CT is able to form systematic mindsets, encourage self-evaluation, and improve the quality of learning design and implementation. This study recommends strengthening practice-based and reflection-based CT training in prospective teacher education.

Introduction

In this 21st century, teachers have many important roles, namely being leaders, making adjustments or adaptations to changes in the education system, and creating an effective classroom environment (Kizi & Ugli, 2020). Teachers also play an important role in facilitating, limiting, and balancing students' participation rights (Zak-Doron & Perry-Hazan, 2024).

Therefore, empowering teachers as agents of social change can lead to profound individual and social transformation (Butera et al., 2021). In today's era of increasingly rapid technological development, teachers also play an important role in designing an educational system that can promote computational thinking skills among students (Nuzzaci, 2024).

Why is that? Because computational thinking allows individuals to solve complex problems efficiently by breaking them down into parts (Chakraborty, 2024) and align with modern scientific practices (Krakowski et al., 2023). Computational thinking also plays a role in improving logical reasoning and creativity in students (Juškevičienė et al., 2021). So that it can be used as an effort to equip students to face the various challenges they face in life (Safi'i et al., 2022). Through creative thinking skills, a person can generate ideas (Dumas et al., 2024) as well as increasing well-being and new, more positive experiences (Fiori et al., 2022). In addition, the ability to think creatively can also activate thought patterns that change perspective and empathize with the perspectives of others (Yang & Hung, 2021). In this way, it will be able to support the success and progress of oneself, the organization, and society as a whole (Ayasrah et al., 2023).

In language learning, in today's digital era, the integration of computational thinking not only directs students to code, but also can equip students to be skilled in solving problems and able to use logical reasoning (Dwivedi et al., 2024; Šumonja, 2023; Wells, 2023; Vassallo & Busuttil, 2023). To optimize the successful implementation of computational thinking in students, it is essential to have teachers' understanding and ability to implement it. This is crucial because integrating computational thinking into education, particularly language learning, will guide teachers in adapting to the digital era and encourage innovation in learning (Isaksson Persson & Pears, 2023). Therefore, providing computational thinking training for prospective teachers, particularly language teachers, is crucial. This will effectively enhance students' problem-solving, creative, and logical thinking skills.

Although various studies have demonstrated the positive impact of implementing computational thinking (CT) on problem-solving skills, studies on prospective teachers' experiences in implementing CT, particularly in the context of prospective Indonesian language teachers, are still relatively limited. Understanding educators' direct experiences in implementing CT, particularly through reflection on successes, failures, and challenges, can provide valuable insights into the transformative potential of this framework, as well as teaching perspectives and practices. For most teachers, utilizing CT is not simply a technical process, but rather a profound cognitive process that influences how problems are understood, analyzed, and solved in educational contexts.

Furthermore, the integration of CT into teacher professional development can be a catalyst for improving the quality of education and learning. This improvement includes a transition from a teacher-centered approach to student-centered learning, the adoption of an interactive mindset, and the design of learning experiences that reflect the complexities of the real world. However, these learning changes often face challenges due to various obstacles, such as conceptual misconceptions, limited digital competencies, and resistance to change. This situation requires critical examination to strengthen the design of teacher training programs and future curriculum development.

This article aims to explore educators' reflective experiences in integrating CT into problem-solving, highlighting the cognitive transformations, instructional reflections, and practical adjustments that occur during the process. Using a reflective approach and narrative analysis, this study focuses on three main questions:

1) What interesting experiences have prospective Indonesian language teachers had in implementing CT?
2) What are the forms of failure faced by prospective Indonesian language teachers in implementing CT?
3) What changes in the way of thinking did prospective Indonesian language teachers experience after implementing CT?
4) What are some improvements in learning methods that can be made after implementing CT in Indonesian language learning?

Method

Research design

This research employed a qualitative approach with a reflective-narrative study design. This approach was chosen to explore the participants' personal and subjective experiences in understanding and implementing Computational Thinking (CT) in problem-solving, as well as the cognitive and pedagogical changes they experienced during the process. Through in-depth narratives and reflections, it is hoped that a comprehensive understanding of the dynamics of thinking and the shift in teaching paradigms triggered by an understanding of CT will be gained.

Participants

Participants in this study consisted of 19 prospective teachers who attended a course on CT in the context of Indonesian language learning held at a private university in Jakarta, Indonesia. The participants were selected purposively based on certain criteria, namely: (1) having attended CT training or lectures for at least one semester; (2) having experience applying CT in solving learning problems; and (3) being willing to write a narrative reflection of their experiences.

This qualitative study involved 19 participants (N = 19), with the sample size determined based on the principle of data saturation. Data collection was concluded when no new themes or analytical insights emerged and thematic patterns had stabilized. Ethical considerations were strictly observed; all participants provided informed consent, confidentiality was ensured through the use of pseudonyms, and all data were securely stored and used solely for academic purposes.

Data collection technique

The data collection technique was carried out by collecting written reflection documents carried out by prospective Indonesian language teachers after implementing CT in learning. Each participant was asked to write a reflective narrative about their experience in learning and implementing CT. This reflection covered three main aspects: (a) the pleasant experiences felt by prospective Indonesian language teachers, (b) failures or various obstacles faced by prospective Indonesian language teachers in implementing CT, (b) changes in the way of thinking felt, and (c) potential improvements in teaching practice after studying CT.

Data analysis

Data were analyzed using a thematic analysis approach using NVivo. The analysis stages used were based on procedures popularized by Braun & Clarke (2019), which consists of (1) repeatedly reading the reflection data and interview transcripts to understand the entire content; (2) coding the units of meaning; (3) identifying the main themes that emerged from the participants' experiences; (4) reviewing and modifying the themes to ensure coherence; and (5) compiling a thematic narrative that represents the findings. Data validity is maintained

through member checking, namely by asking participants to review the researcher's interpretation of their experiences.

Results and Discussion

Based on the research conducted, it was found that the implementation of computational thinking in Indonesian language learning by prospective Indonesian language teachers has generated very diverse impressions. The following are reflections on the experiences of prospective Indonesian language teachers, divided into four categories: interesting experiences, failures, changes in thinking, and improvements in learning after implementing CT. The findings and discussion of these four aspects are explained below.

1. Reflection on interesting experiences in implementing CT

The use of CT in Indonesian language learning by prospective Indonesian language teachers participating in the training program resulted in a number of interesting experiences. The following is a thematic coding of these interesting experiences based on the prospective teachers' reflections.

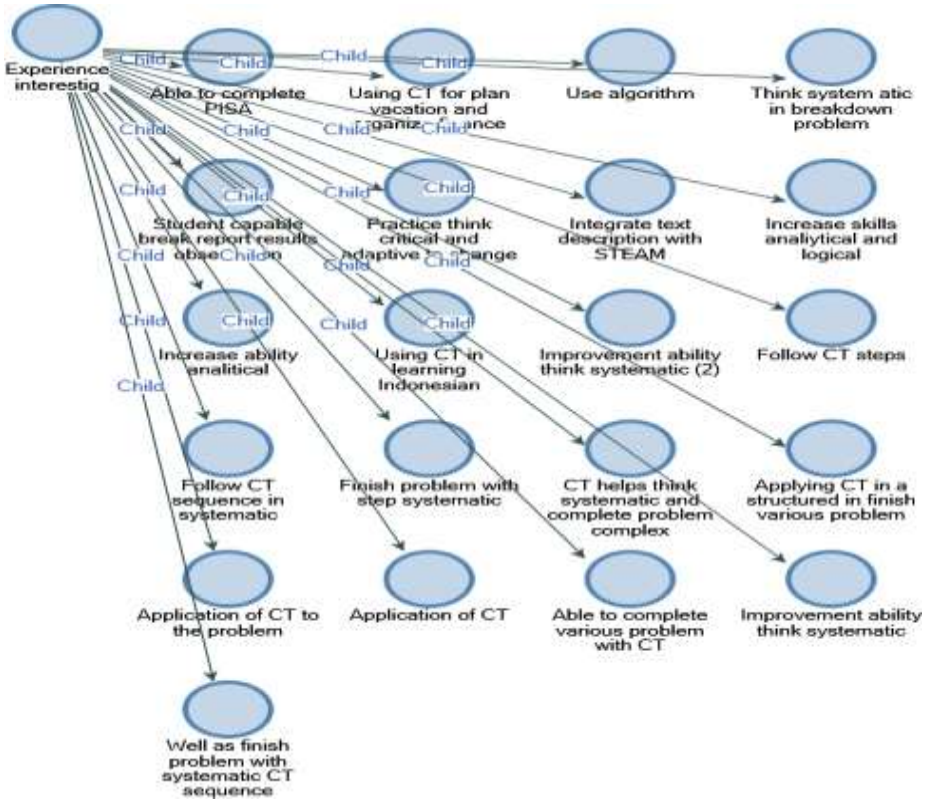

Figure 1. Reflection of interesting experiences in implementing CT

The implementation of the Computational Thinking (CT) approach in the Indonesian language learning process by prospective teachers has generated various interesting experiences that demonstrate the positive impact of CT integration, namely in the form of improving the quality of learning and developing the professional competencies of prospective teachers. Based on the results of the reflection coding, these experiences can be analyzed into five main themes: improving thinking skills, contextualizing CT in real life,

strengthening problem-solving skills, and increasing interest, motivation, and self-confidence.

Regarding the improvement of thinking skills, the results of the prospective teachers' reflections illustrate that the application of CT significantly contributes to their systematic and analytical thinking skills. This is reflected in various reflective statements that emphasize how CT helps prospective teachers break down complex problems into simpler, more structured steps. CT enables prospective teachers to think in an organized manner, recognize patterns, and draw conclusions based on logical analysis. For example, prospective teachers expressed that after integrating CT into their learning, they are now better able to "think systematically in problem breakdown" and "follow CT steps" in completing learning assignments. This ability is crucial in the context of language learning, where text comprehension and analysis, as well as logical argumentation, are key elements. This is certainly highly relevant to the concept and research findings on CT implementation, namely enables individuals to solve complex problems efficiently by breaking them down into their component parts (Chakraborty, 2024).

The next teacher reflection was on CT contextualization in real life. This emphasized that the experience of using CT is not limited to academic issues but can also be applied to life issues outside of academic activities. Several prospective teachers expressed that CT can be used to plan vacation activities and complete other complex tasks outside the classroom. Reflections such as "using CT to plan vacation and organize confidence" indicate that CT not only improves cognitive skills but also practical skills that can increase self-confidence and independence. This contextualization shows that CT is able to foster lifelong learning skills, an important competency in facing the challenges of the 21st century. This is as stated by Juškevičienė et al. (2021), that CT plays a role in improving logical reasoning and creativity.

Furthermore, the prospective teachers' reflections on the use of CT demonstrated the strengthening of complex problem-solving skills. The prospective teachers' reflections illustrated how they learned to develop step-by-step strategies using a systematic CT sequence. Reflections such as "CT helps think systematically and complete complex problems" and "I am well-equipped to finish problems with a systematic CT sequence" indicate that the prospective teachers experienced increased capacity in developing structured and efficient solutions. In the context of Indonesian language education, this is important to encourage students to think critically in understanding text structure, developing arguments, and resolving conflicts of interpretation in language learning. As stated in the introduction, creative thinking ability, a person can produce ideas (Dumas et al., 2024) as well as increasing well-being and new, more positive experiences (Fiori et al., 2022). In addition, the ability to think creatively can also activate thought patterns that change perspective and empathize with the perspectives of others (Yang & Hung, 2021).

The next prospective teacher's experience was integrating CT into Indonesian language and text literacy learning. Several prospective teachers expressed their success in integrating CT into descriptive text learning through analytical language use and the development of critical thinking skills. This shows that CT can function as a pedagogical approach that supports a deep understanding of the structure and meaning of texts, as well as increasing student creativity in composing written works. The use of CT also helps teachers in designing learning steps that are more effective and responsive to students' learning needs. This is in line with what was expressed by Yadav et al. (2017), that the

algorithmic principles in CT can train students to organize their thought processes in writing procedural, expository, or argumentative texts.

Furthermore, the prospective teachers' subsequent enjoyable experiences when using CT in their learning were increased interest, motivation, and self-confidence. The prospective teachers felt more challenged and actively engaged in the learning process. Phrases such as "experience interesting" emerged as key nodes in the coding network connecting the various positive impacts of CT. Furthermore, reflections related to "organize confidence" indicated that the CT approach also fostered self-confidence in the prospective teachers, particularly when they successfully completed complex tasks independently. This self-confidence can be a crucial asset for improving and optimizing learning outcomes. This is as expressed by Natiqi (2024), that motivation plays an important role in learning by stimulating and directing behaviour towards specific goals.

The findings, including the enjoyable experiences of prospective teachers, emphasize the importance of integrating Computational Thinking into teacher education, particularly in language learning. Computational Thinking is not only relevant to science and technology but also highly applicable to developing literacy, critical thinking, and problem-solving in language contexts. Therefore, prospective teacher education needs to systematically design learning programs that integrate Computational Thinking so that future teachers have complex, reflective, and innovative thinking skills.

2. Reflection on failure in implementing CT

While providing a variety of engaging experiences for prospective teachers, the use of CT in Indonesian language learning also faces various obstacles, including a number of experiences that illustrate the failures of prospective teachers in implementing CT. The following are various failures experienced by prospective Indonesian language teachers when implementing CT in their learning.

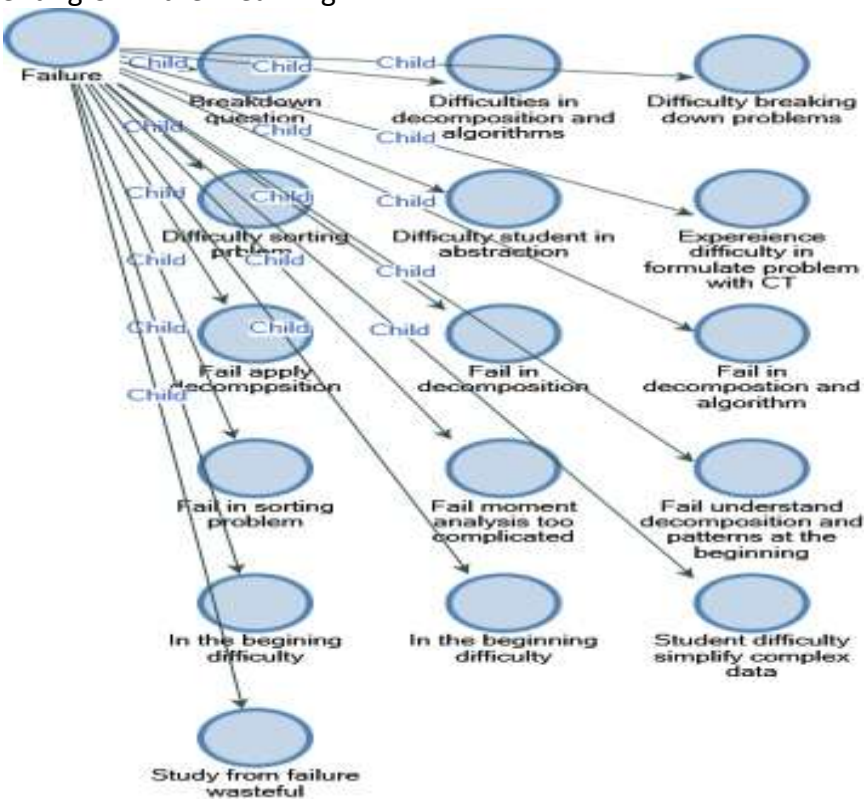

Figure 2. Reflection on failure in implementing CT

Based on the data above, it can be seen that although the implementation of Computational Thinking (CT) provided a number of interesting experiences, prospective Indonesian language teachers also faced various challenges and failures in the process. The prospective teachers' reflections revealed critical aspects that need to be considered in the process of integrating CT into educational practice, particularly in the field of language learning. These findings can be grouped into several themes: difficulties in the decomposition and algorithm processes, difficulties in simplifying and abstracting problems, obstacles in the initial stages, and failures in developing solution steps.

One of the most dominant challenges is the failure to apply decomposition, which is breaking down large problems into smaller, manageable parts. Reflections such as "fail in decomposition," "fail to apply decomposition," and "fail in decomposition and algorithm" indicate that many prospective teachers are not yet accustomed to the systematic and step-by-step thinking that is the core of CT. This failure is also evident in the reflections "Difficulties in decomposition and algorithms" and "Fail to understand decomposition and patterns at the beginning." This indicates that the basic concepts of CT have not been fully understood and internalized, especially in the early stages of learning, making it difficult for participants to design logical and sequential learning solutions. These findings align with research by Voogt et al. (2015) that many teachers have difficulty understanding CT concepts in depth. Instead of integrating CT into the learning process, they tend to revert to conventional methods due to a lack of training or technical support.

Difficulty simplifying and abstracting problems is also an unpleasant experience for most prospective teachers when using CT in their learning. Many prospective teachers struggle with abstraction, which involves filtering out important information and ignoring irrelevant information. Reflections such as "student difficulty in abstraction" and "student difficulty simplifying complex data" demonstrate the challenges in filtering and simplifying information. Therefore, prospective teachers need to practice more on how to extract key information from complex texts.

Furthermore, prospective teachers also encountered obstacles in the initial stages of using CT. Reflections such as "in the beginning difficulty" emerged repeatedly, indicating that the initial stage of the CT process is the most challenging phase. In this phase, participants often experienced confusion in analyzing overly complex problems, which is implied in the coding "fail moment analysis too complicated." Furthermore, some prospective teachers also experienced difficulty in formulating problems accurately (experience difficulty in formulating problems with CT). This condition demonstrates the importance of intensive initial guidance and the use of concrete examples that can help prospective teachers understand and apply CT principles from the beginning. This is in line with what was expressed by Dreer-Goethe (2025). that mentoring relationships that are established early and carried out systematically improve the quality of engagement, psychological safety, and the ability of participants to process information and conceptualize teaching practices.

Furthermore, some teachers still experience failures during the development of problem-solving steps. Several prospective teachers admitted to failing to develop logical and systematic problem-solving steps. This is evident in reflections such as "failure in sorting problems" and "difficulty sorting parts." This failure hinders achieving effective and efficient solutions because their thought processes are disorganized. Some prospective teachers even feel that their failures are futile or do not provide meaningful learning. The

reflection "study from failure wasteful" demonstrates the need to build awareness of the importance of reflection and critical self-evaluation. Without efforts to learn from failure, the process of developing CT is less than optimal. Learning strategies that facilitate reflection on errors will strengthen students' conceptual mastery, cognitive resilience, and persistence (Narciss & Alemdag, 2025).

The failures experienced by prospective teachers in implementing CT reflect pedagogical challenges that need to be addressed systematically. The lack of understanding of the basic components of CT, such as decomposition, abstraction, and algorithmic thinking, needs to be addressed with more structured, practice-based training strategies. Furthermore, reflective support from lecturers or facilitators is needed so that prospective teachers can transform failures into constructive learning materials. In addition to pedagogical interventions, the development of teaching tools, simulation scenarios, and problem-based projects also needs to be implemented to help prospective teachers internalize CT in the context of Indonesian language learning in a more contextual and meaningful way.

3. Reflection on changes in thinking after implementing CT

The use of CT in Indonesian language learning has brought about various positive changes in ways of thinking. CT has been perceived to have numerous benefits in real life. Below are various CT experiences that have impacted the thinking of prospective Indonesian language teachers.

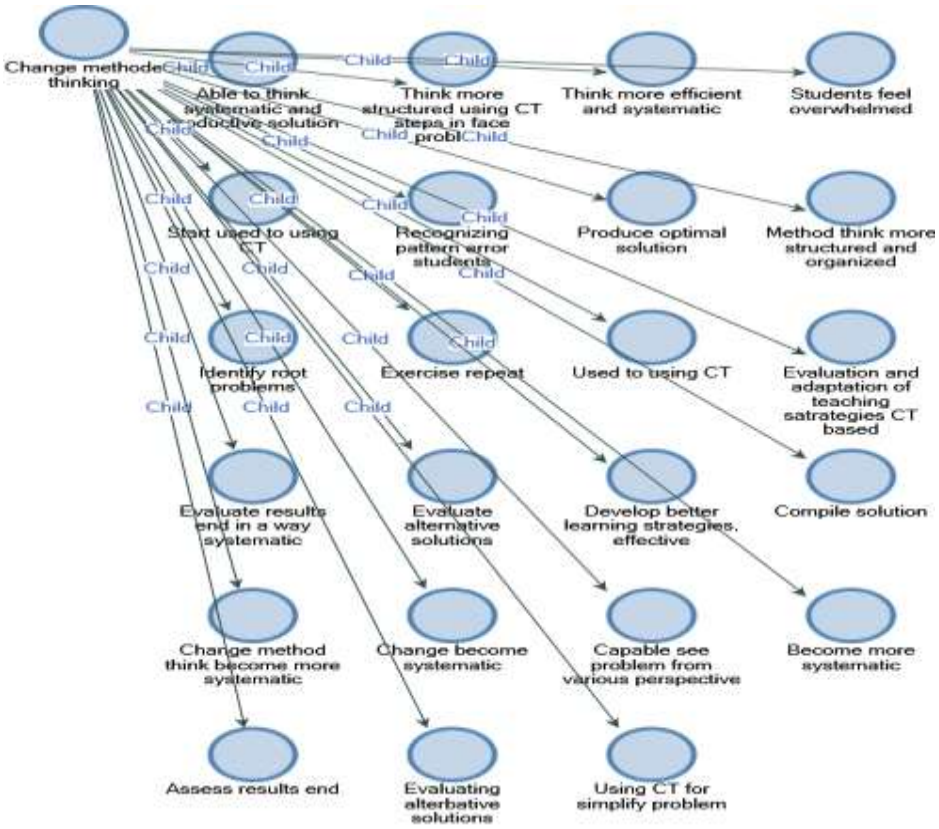

Figure 3. Reflection on changes in thinking after implementing CT

Reflections on the use of CT also illustrate that CT can bring about changes in thinking. Many prospective teachers expressed that they experienced a fundamental shift

in their thinking patterns, from spontaneous or intuitive to more systematic and logic-based. This is evident in reflections such as "able to think systematically and deductively about solutions," "think more structured using CT steps in facing problems," and "change method of thinking to become more systematic." This process can be understood through the lens of metacognition, namely an awareness that allows someone to recognize what they are doing, why they are doing it, and how their learning abilities can be adapted to different contexts (Mondal, 2023). CT requires someone to not only solve problems, but also to design thinking strategies, evaluate the process, and reflect on the results. Teachers' understanding of students' thinking processes also plays a role in helping them achieve higher-order thinking skills that are essential in language learning (Anderson & Krathwohl, 2001).

CT integration also encourages prospective teachers to evaluate and adapt their learning strategies. Reflections such as "evaluating and adapting CT-based teaching strategies" and "developing better, more effective learning strategies" demonstrate that prospective teachers are beginning to recognize the need for learning based on problem-solving, organizing ideas, and careful planning. This aligns with the Design Thinking approach, which consists of five stages: empathizing, defining, ideating, prototyping, and testing (Saravanan et al., 2022). By adopting CT, prospective teachers begin to design learning experiences that are more responsive to student needs and learning outcomes.

Reflections such as "evaluate alternative solutions," "assess end results," and "able to see problems from various perspectives" demonstrate that CT encourages flexible thinking and the ability to view problems from different perspectives. This reflects the theory of Self-Regulated Learning, which asserts that individuals set their own goals, strategies, and monitoring in their learning process (Zimmerman, 2002). In this context, prospective teachers not only implement the strategies provided but are also able to evaluate and select the most effective strategies appropriate to the context. This is crucial in Indonesian language learning, where text comprehension, interpretation of meaning, and critical assessment are key aspects.

Reflections such as "identifying root problems" and "recognizing student error patterns" demonstrate that CT develops prospective teachers' sensitivity in diagnosing learning problems and analyzing error patterns. This relates to the formative assessment approach, a continuous process that involves collecting, interpreting, and using information to adapt instruction to students' learning needs (Heritage, 2021). In this framework, the teacher's role is not only as a material deliverer, but also as a facilitator who is able to diagnose learning needs and direct students to develop comprehensive language competencies (Brown, 1994).

The next reflection of the prospective teachers' changing way of thinking was their willingness to try something new repeatedly to become more knowledgeable and skilled. Some prospective teachers initially found it difficult to carry out learning using the CT approach, as expressed in the statement "students feel overwhelmed." However, the prospective teachers gradually showed adaptation through repeated practice ("exercise repeat") and began to become accustomed to using CT in learning tasks ("used to using CT"). This habituation process supports the assumption of constructivism theory, that knowledge does not emerge instantly, but is built gradually through active experience, social interaction, and self-reflection. In this context, computational thinking (CT) is understood not only as a set of technical skills, but as a mental habit, namely a way of thinking that develops through repeated practice and meaningful learning integrated in

various contexts (Yadav et al., 2016; Brennan & Resnick, 2012; Shute et al., 2017; Solomon et al., 2020).

These findings reinforce the urgency of systematically integrating CT into pre-service teacher education, particularly in the context of language learning. CT not only equips pre-service teachers with complex problem-solving skills but also fosters the reflective, adaptive, and collaborative skills necessary for contemporary teaching practices. Teacher training should be designed with contextual CT practices in mind, project-based learning, and a focus on reflective thinking processes. This will produce Indonesian language teachers who are not only proficient in content but also excel in logic-based and creative learning design.

4. Reflection on improvements in teaching after implementing CT

Besides impacting individual thinking patterns, the use of CT can also be used to improve teaching methods. Some of the changes or improvements that prospective teachers can make are illustrated in the thematic coding of the following reflections.

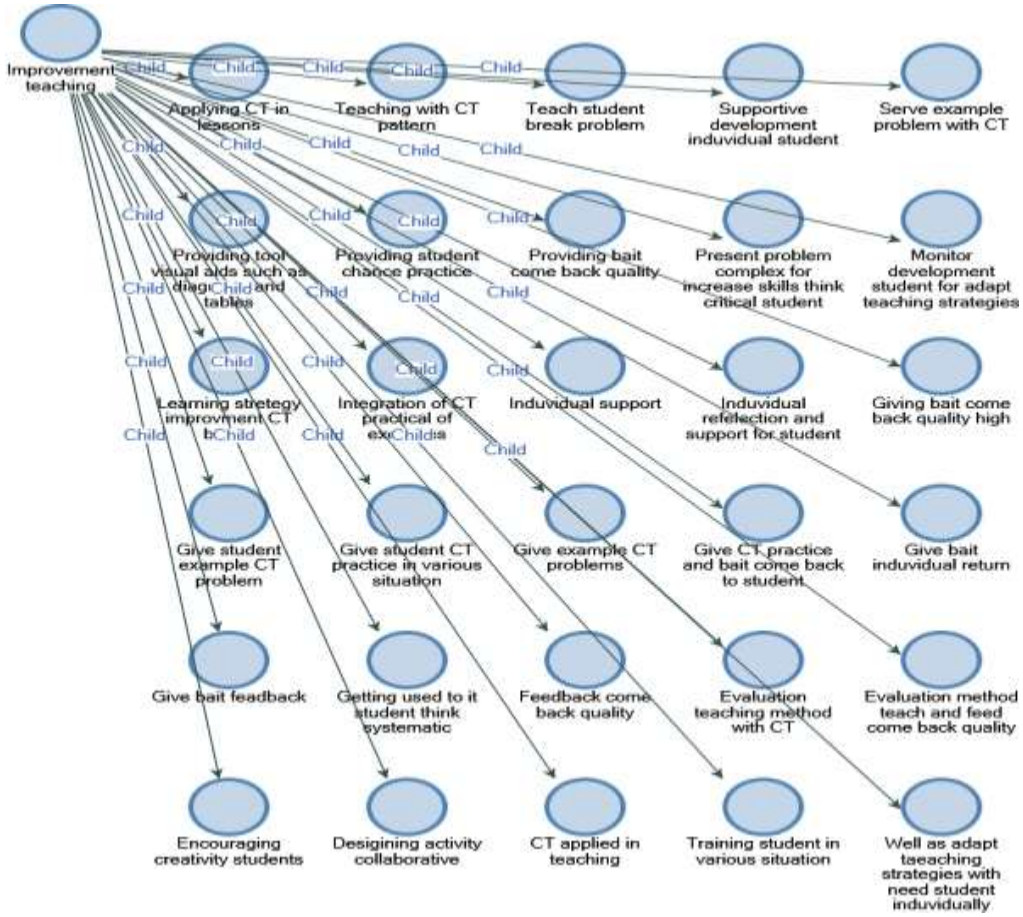

Figure 4. Reflection on improvements in teaching after implementing CT

Based on the mapping of reflections on the experiences of prospective teachers regarding how CT can be projected to make improvements in learning, it can be seen that the implementation of Computational Thinking (CT) in the Indonesian language learning process by prospective teachers not only facilitates the mastery of logical and systematic thinking concepts, but also creates significant changes in teaching strategies and quality. The reflections of prospective teachers show that the application of CT contributes

significantly to the improvement of more structured, contextual, and adaptive learning methods. This finding is in line with various modern learning theories that emphasize the importance of reflection-based practices, active student participation, and differentiated approaches.

Reflections such as "Applying CT in lessons," "Teaching with CT patterns," and "CT applied in teaching" demonstrate the conscious integration of CT principles into the learning planning process. Prospective teachers begin to structure learning activities based on CT stages such as decomposition, pattern recognition, abstraction, and algorithmic thinking. These implementation efforts will be a strategic step in efforts to improve the quality of learning. This is consistent with previous research findings that the use of CT can improve the ability to think logically and systematically, and solve complex problems into simpler parts.

CT also provides a systematic framework for teachers in designing meaningful and contextual problem-solving-based learning. Indonesian language learning, which is rich in activities such as understanding, analyzing, and producing texts, is well suited to CT's process-oriented and logical thinking patterns. This, for example, can be applied in learning to identify the main points of a reading and writing expository texts. Teachers can teach students to first analyze the expository text and then guide them in identifying important parts within the text's structure. Afterward, during writing activities, teachers can direct students to draft an expository text according to the text's structure and then construct it step by step.

In addition, several reflections underscored the importance of providing consistent practice, such as “Providing students the chance to practice,” “Give students CT practice in various situations,” and “Getting students used to it and thinking systematically.” Repeated practice is a form of deliberate practice that emphasizes cognitive engagement, close supervision, and continuous improvement based on feedback (Ericsson, 2020; Macnamara et al., 2014). The provision of training should also involve relevant collaborative and simulation-based activities, so that learning becomes more interactive and meaningful. Collaborative and team-based learning enhances the educational experience by addressing real-world problems, fostering student citizenship, and developing essential skills (Manion et al., 2020). This method increases student engagement, critical thinking, and application of theoretical knowledge, making learning more dynamic and relevant (Mukhtoralieva, 2025).

The next reflection on improvements in learning related to CT implementation is the provision of feedback. Prospective teachers noted that providing feedback and prompting questions played a crucial role in improving the quality of students' learning. Reflections such as "Give bait feedback," "Give CT practice and bait come back to students," and "Feedback come back quality" indicate that this strategy is able to stimulate students' critical and exploratory thinking. Feedback from lecturers significantly increased student motivation (Rodriguez-Largacha et al., 2015). Personalized motivational feedback based on student achievement goals significantly increases motivation and satisfaction in online learning (Wang & Lehman, 2021). Research shows that when feedback facilitates problem decomposition, pattern recognition, and algorithmic thinking, students tend to be more active in analyzing language and constructing more complex linguistic responses (Román-González et al., 2017; Shute et al., 2017).

Furthermore, reflections on improving learning in integrating CT include adapting learning based on individual needs. Reflections such as "Supporting individual student

development," "Evaluating teaching methods and feedback quality," and "Well-adapted teaching strategies to individual student needs" reflect an awareness of the importance of a differentiated approach to learning. Tomlinson (2014) emphasizes that differentiated learning has proven to be an essential strategy in responding to the diversity of students' backgrounds, readiness, and learning profiles. Recent research shows that by implementing differentiated approaches—such as readiness-based grouping, tailoring content and learning processes, and multisensory learning environments—teachers can help each student learn meaningfully and effectively (Dhakal, 2024; Agustina et al., 2025; Ramilo et al., 2025).

The prospective teachers also showed a tendency to evaluate their teaching strategies. Reflections such as "Evaluate teaching method with CT," "Evaluate method teach and feedback quality," and "Monitor student development for adaptive teaching strategies" demonstrate the practice of reflective teaching, namely the teacher's ability to continuously evaluate and refine the learning approach used. Formative assessments designed with process considerations, such as self-assessment, peer assessment, and reflective rubrics, can improve student self-regulation, cognitive engagement, and overall learning motivation (Sortwell et al., 2024). A recent meta-analysis in medical education confirmed that formative assessment that integrates continuous feedback allows for real-time adjustment of teaching strategies as well as the development of critical thinking processes and student engagement (Sirianansopa, 2024). In the context of Indonesian language education, this evaluation is important for adapting teaching methods to variations in students' abilities to understand texts, think critically, and produce written ideas.

This reflection strengthens Computational Thinking's position as a pedagogical approach that can comprehensively improve the quality of teaching. CT integration not only equips students with higher-order thinking skills, but also enhances teachers' abilities to design responsive, problem-based, and collaborative learning, manage the learning process through structured exercises and in-depth reflection, provide constructive and contextual feedback, address individual student needs, and continuously evaluate and improve learning strategies. Therefore, teacher education programs need to integrate CT training systematically and practice-based to produce Indonesian language teachers who are not only competent in content but also innovative in teaching strategies.

Conclusion

The reflections of Indonesian pre-service language teachers on the implementation of CT in instruction revealed a meaningful pedagogical transformation. Through narratives of success, failure, cognitive change, and instructional refinement, CT emerged as more than a set of technical skills. It functioned as a conceptual framework that encouraged systematic thinking, self-reflection, and innovation in lesson planning. While initial challenges related to decomposition, abstraction, and algorithmic structuring were commonly encountered, participants gradually developed new cognitive and instructional strategies that allowed them to engage with complexity in language learning contexts.

The study demonstrates that CT supports the development of metacognitive awareness, adaptive thinking, and reflective practice among teacher candidates. By embedding CT into the instructional design process, participants shifted from conventional

teaching routines to more student-centered and inquiry-driven pedagogies. These shifts indicate that CT contributes not only to cognitive growth but also to the evolution of teacher identity as reflective, autonomous, and forward-thinking educators. This research thus contributes to the growing body of literature that situates CT not merely within computing or STEM fields, but as a cross-disciplinary pedagogical tool with strong applicability in language education.

Given these findings, it is recommended that teacher education programs formally integrate CT into their curricula through practice-based training, structured reflection, and collaborative design tasks. Future studies may build on this work by exploring how CT influences long-term teaching efficacy, student learning outcomes, and cross-disciplinary instructional models. Additionally, further research is needed to investigate the role of digital platforms and simulation environments in strengthening CT competencies among pre-service teachers in diverse educational and sociocultural settings. By advancing both theoretical understanding and applied practice, this study affirms the value of CT in preparing educators for the cognitive and instructional demands of 21st-century classrooms.

Authorship Contribution Statement

Fill in contributions from all authors by following the steps below. Safi'i: Generating ideas and conceptualization, developing the research design, and managing the entire research process. Wahdini: Writing the literature review, organizing the discussion and conclusion, supervising the research, translating, and final editing.

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