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The Relationship between Computational Thinking Concept and Computational Thinking Skills among Trainee Teachers: A Conceptual Paper

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Abstract
Computational thinking (CT) is the crucial skill for the 21st century which is gaining increasing significance in our rapidly advancing technological world. Therefore, since the demand for CT has increased in modern education systems, Malaysia also incorporated computational thinking skills into its curriculum to align with global 21st-century educational trends. While understanding CT concepts is foundational, the ability to apply these skills effectively can vary based on training quality and individual attitudes. A few studies have examined whether CT attitudes influence CT skills. This study is conducted to investigate the relationship between trainee teachers' perception of CT concepts and their CT skills. The study focuses on six core CT concepts: Logic, Algorithms, Decomposition, Pattern Recognition, Abstraction, and Evaluation. The study employed a correlational research design with quantitative survey method was used; items were constructed in questionnaire to acquire teachers' perception and their knowledge about CT concept, while Bebras Challenge Tasks to assess their CT skills. 100 science trainee teachers from all IPGM over Malaysia are targeted to complete the survey form and Pearson correlation test is used to analyze the survey data. Results from this study provide insights into how CT concepts correlate with CT skills and the perceptions of trainee teachers towards CT concepts.

Keywords: Computational Thinking Concepts, Computational Thinking Skills, Science Education

Introduction

CT is the crucial skill for the 21st century which is gaining increasing significance in our rapidly advancing technological world (Curzon *et al*., 2009; Tabesh, 2017) [10, 32]. Therefore, since the demand for CT has increased in modern education systems, Malaysia also incorporated CT skills into its curriculum to align with global 21st-century educational trends (Ung *et al*., 2022) [34]. In the 21st century, the rapid development of transportation and communication technologies has significantly interconnected global economies, cultures, and communities. This integration has enhanced cross-cultural understanding, boosted international trade, and promoted intellectual exchange (Ahamer & Kumpfmüller, 2014) [2]. To remain competitive in the global digital economy, countries worldwide, including Malaysia, have increasingly focused on nurturing higher-order thinking skills (HOTS) within their educational systems. However, the latest Programme for International Student Assessment (PISA) results revealed a 6.26% drop in Malaysia's average scores, from 431 in 2018 to 404 in 2022 (OECD, 2023) [23].

Given this challenge, the integration of technology has become an essential aspect of fostering critical thinking and problem-solving skills among students. One important field gaining prominence is the incorporation of CT into education, particularly in Science and Mathematics. CT, defined as a cognitive process encompassing problem-solving and analytical skills rooted in computer science, offers a systematic approach to tackling complex challenges (Gabriele *et al*., 2019; Kale *et al*., 2023) [13, 19]. By breaking down intricate problems into manageable components, CT encourages innovative solutions—making it invaluable in scientific inquiry, experimentation, and addressing real-world issues (Sung *et al*., 2017) [31].

Research highlights the benefits of incorporating CT in education. It helps students find novel solutions to seemingly unsolvable problems, improves teaching and learning activities, and builds students' confidence in tackling open-ended challenges (Weintrop *et al*., 2016) [35]. In Malaysia, CT was introduced in 2017 through the Basic Computer Science subject for Form 1 students, focusing on techniques such as decomposition, pattern recognition, abstraction, generalization, and and algorithms (Zaibon & Yunus, 2019; Salman Firdaus Sidek *et al*., 2020) [38, 29]. This integration aligns with the country's commitment to fostering digital literacy in the 21st century (Ogegbo & Ramnarain, 2022; Ung *et al*., 2022) [24, 34].

Despite the recognized importance of CT in fostering problem-solving skills, Malaysia's educational system faces several challenges in its implementation. Although CT was introduced in 2017 as part of the Basic Computer Science subject for secondary students (Zaibon & Yunus, 2019; Salman Firdaus Sidek *et al*., 2020) [38, 29], many trainee teachers struggle with its practical application (Cerovac & Keane, 2023) [8]. While trainee teachers often understand CT concepts, they lack the skills to integrate them effectively into their teaching due to a focus on theory over practice in training programs (Jacques & Howle, 2023) [17]. Furthermore, obstacles such as limited teacher expertise, inadequate facilities, and time constraints impede CT integration in schools (Weintrop *et al*., 2016; Kite & Park, 2023) [35, 20]. In primary schools, the introduction of CT is still relatively new, particularly in subjects like science and math (Othman *et al*., 2023; DeSchryver & Yadav, 2015) [25, 12]. Additionally, there is a gap in understanding how the perception of trainee teachers toward CT concept can effectively influence CT skills level. While previous studies have often focused on one or the other, less attention has been given to their relationship (Adawi, 2021; Ahmad Shahril Mohd Napiah, 2021; Butler & Leahy, 2021) [1, 3, 7]. This research could explore the relationship between CT concepts and Ct skills, which the perception of trainee teacher towards CT concepts and CT skills as the intelligence level.

Research Objective

The primary objective of this research is to explore and understand the current state of trainee teachers perceptions towards CT skills in the context of science education. The primary objectives are as follows:

1. Identify the perception of trainee teachers towards integrating CT concept in teaching and learning among trainee teachers.
2. Identify the level of CT skills among trainee teachers.
3. Identify the relationship between perception of CT concept and CT skills.

Research question

1. What is the level of perception of trainee teachers' towards integrating CT in teaching and learning?
2. What is the level of trainee teachers' CT skills?
3. Is a relationship between perception of CT concepts and CT skills?

Hypothesis

To investigate the questions of the research study, the researcher developed the following hypotheses:

H_{01}: There is no significant relationship between CT concept and CT skills.

Literature Review

The definition of Computational Thinking (CT) has evolved over time, shaped by technological advancements and educational needs. Initially, CT was introduced in the 1980s by Seymour Papert, as a set of computational ideas used in designing computer hardware, software, and calculations (Papert, 1980) [26]. Wing (2006) [36] expanded the definition, positioning CT as a fundamental skill for everyone, not just computer scientists. According to Wing (2006) [36], CT is foundational not only for computing but also for developing a systematic approach to complex problem-solving across various fields.

The key CT concepts include decomposition, pattern recognition, abstraction, algorithm design, and evaluation. Decomposition involves breaking down complex problems into smaller, manageable parts, allowing individuals to focus on and tackle discrete elements of a problem systematically. Pattern recognition, on the other hand, enables individuals to identify patterns and trends within information, generalize solutions, and apply previous experiences to new, similar situations, thus enhancing efficiency and predictability in problem-solving. Abstraction focuses on essential information while disregarding irrelevant details, enabling individuals to concentrate on the core aspects of a challenge and develop a streamlined approach to solutions. Algorithm design revolves around creating step-by-step procedures to address specific problems, guiding systematic exploration and solution development. Evaluation, the final concept, involves continuous assessment and refinement of solutions to improve effectiveness and efficiency, ensuring the approach remains adaptive and responsive to evolving problem conditions. Together, these CT concepts foster an analytical and creative approach to problem-solving, equipping individuals with the tools to tackle challenges across domains beyond computing, such as mathematics, science, and the social sciences (Barefoot, 2014; Rubinstein & Chor, 2014) [4, 28]. These concepts establish a structured problem-solving mindset, enabling learners to develop innovative approaches to complex challenges. CT is now viewed as a cognitive skill that supports critical thinking and innovation (Li *et al*., 2020) [21]. It emphasizes computational methods not just as a way of operating computers, but as a framework for solving a wide range of problems in different domains, from science and mathematics to social studies and the arts (Rubinstein & Chor, 2014, Weintrop *et al*., 2016) [28, 35].

In recent years, Malaysia has integrated CT into its educational curriculum as part of the Malaysia Education Blueprint 2013-2025 (MOE, 2014) [22]. CT has been recognized as a vital component of modern education, especially in science, technology, engineering, and mathematics (STEM) subjects. The inclusion of CT in teacher training programs is essential, as it prepares educators to introduce these problem-solving frameworks to students, fostering skills that align with the demands of a technology-driven world (Gabriele *et al*., 2019) [13]. Research shows that trainee teachers who are well-versed in CT concepts are better equipped to teach these skills, thus promoting students' analytical thinking and problem-solving abilities from a young age (Ogegbo & Ramnarain, 2022; Peracaula-Bosch & González-Martínez, 2024) [24, 27]. However, studies show that many trainee teachers face challenges in understanding CT concepts and effectively integrating them into classroom practices (Jacques & Howle, 2023) [17]. Teachers need adequate training to bridge the gap between theory and practice. Research also suggests that teachers' perceptions of their CT skills affect their ability to apply these skills in teaching (Humble & Mozelius, 2023) [16].

In the context of relationship, a deeper grasp of CT concept can significantly enhance one's capacity to apply CT skills in real-world scenarios. For example, Brennan and Resnick (2012) [6] suggest that mastery of CT concepts improves an individual's ability to effectively employ CT skills in problem-solving tasks. Similarly, Grover and Pea (2013) [14] highlight the critical role of conceptual understanding in nurturing computational thinking skills among learners. Guzdial and Soloway (2014) [15] found that providing students with a solid conceptual foundation, particularly in algorithms and problem decomposition, enhanced their ability to apply these skills in programming tasks. Thus, the interplay between CT concepts and skills is vital for fostering effective problem-solving abilities.

Trainee teachers who receive targeted CT training demonstrate improved conceptual understanding, which is important for integrating CT into their teaching practices (Peracaula-Bosch & González-Martínez, 2022). A study found that teachers with prior CT training and experience, regardless of their subject area, are more likely to apply CT skills effectively, (Tagare, 2023). The prior experience, training duration, and attitudes towards CT are some of the factors that affects one's ability to apply CT skills. For instance, time spent on CT training and perceptions of content difficulty are important predictors of skill application (Jin & Cutumisu, 2023) [18]. Furthermore, positive attitudes towards CT correlate with enhanced application skills, indicating the need of creating a supportive learning environment (Cutumisu, 2021) [11].

Methodology

Population and Sampling

The study employed a purposive sampling method targeting trainee teachers majoring in science and enrolled in PPISMP or PISMP programs at the Institute of Teacher Education Malaysia (IPGM). This sampling strategy ensured that the selected participants were relevant to the study's objectives, focusing on future educators who will be responsible for integrating CT into primary science education. A total of 100 trainee teachers participated, recruited through online channels including email and social media platforms (WhatsApp, Facebook, and Instagram), with the survey distributed via Google Forms. Participants were required to meet specific criteria, participants had to be science majors to align with the study's focus on CT in science education and enrolled in PPISMP (Bachelor of Teaching Preparatory Program) or PISMP (Bachelor Degree Program in Teaching) teacher education programs at IPGM.

Instrument

Data collection involved two instruments:

*Questionnair*e

The questionnaire assesses trainee teachers' knowledge about CT concept, using of element in CT concepts, behavioural intentions, and readiness and perceptions of CT integration into education. It includes both Likert-scale items and open-ended questions to gather comprehensive data.

Bebras Challenge Task

This task consists of 15 items specifically selected to evaluate participants' CT skills with grade A (Easy), B (Medium) and C (Hard) (Blokhuis *et al*., 2017) [5]. There is five CT skills exhibited by trainee teachers: Abstraction, algorithmic thinking, decomposition, evaluation, and generalization (Chongo *et al*., 2020) [9]. These items represent real-world problems that require logical thinking, pattern recognition, and problem-solving.

Data Collection

The survey was conducted online through Google Forms, allowing ease of access for participants. The survey link was distributed via institutional channels, and participants were allotted 1.5 hours to complete it. To encourage higher response rates, reminders were sent periodically. A pilot study with 10 science trainee teachers was conducted to evaluate the clarity, relevance, and reliability of the questionnaire and Bebras Challenge Task. Feedback from the pilot study informed refinements to enhance clarity and accuracy.

Data Analysis

The data analysis was guided by the study's three primary research objectives. For Research Objective 1 "What is the level of trainee teachers' perception toward integrating CT in teaching and learning?", which focused on identifying the level of trainee teachers' perception towards integrating CT in teaching and learning, descriptive statistics, specifically the mean and standard deviation, were used. Responses to the Likert-scale items, which ranged from 1 (Strongly Disagree) to 5 (Strongly Agree), were analyzed to calculate the mean score for each item. These mean scores were then categorized into interpretative levels, which helped assess the degree to which trainee teachers perceived CT integration as beneficial within their teaching practice.

For Research Objective 2 "What is the level of trainee teachers' CT skills?", which examined the level of trainee teachers' CT skills, the scores from the Bebras Challenge Task were converted into percentages for each participant. Descriptive statistics, including the mean and standard deviation, were then calculated to summarize the overall level of CT skills among the participants. This analysis provided an overview of their competence in core CT skills.

To address Research Objective 3" Is there a relationship between trainee teachers' perception of CT concepts and their CT skills?", which aimed to measuring relationship between trainee teachers' perceptions of CT concepts and their CT skills, a two-step statistical process was used. First, a normality test was conducted using skewness and kurtosis values, with values between -1 and 1 indicating a normal distribution. This confirmed that the data was sufficiently normal to proceed with correlation analysis. Pearson's correlation coefficient was then employed to examine the linear relationship between the trainee teachers' understanding of CT concepts, as measured by the questionnaire, and their CT skills, as measured by the Bebras Challenge Task. This analysis provided insights into the association between trainee teachers' perceptions of CT concepts and their actual CT competency.

Conclusion

This conceptual paper has outlined the importance of understanding trainee teachers' perceptions and competencies related to Computational Thinking (CT) in primary science education. As CT skills become increasingly essential for fostering problem-solving and logical thinking abilities in students, teachers must be equipped with a solid understanding and practical skills in CT integration. The proposed study aims to address this need by investigating the perceptions and CT skills of trainee teachers in science education, as well as examining the relationship between their understanding of CT concepts and their ability to apply these skills.

Bridging the gap between conceptual knowledge and practical application remains essential for effective CT integration in teaching. Through a quantitative survey methodology, this research will offer insights into how well trainee teachers understand and value CT in the context of primary education, which is critical for designing teacher preparation programs that support CT integration. By examining correlations between perceptions of CT concept and their CT skills level, this study could reveal areas where targeted training is needed, informing teacher education institutions on ways to improve CT readiness among future educators. Ultimately, this research underscores the value of preparing teachers who are not only knowledgeable about CT concepts but also capable of effectively incorporating them into their teaching, promoting a more robust science education framework that meets 21st-century learning demands.

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