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A Preliminary Investigation of the Definition and Components of Computational Thinking in the Malaysian Education Landscape: From Educational Technology Experts' Perspective

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Abstract: This qualitative study explores the definition and essential components of computational thinking (CT) within the Malaysian educational context. Through semi-structured interviews with educational technology experts, the research delves into the nuanced understanding of CT, considering its adaptation to the local educational landscape and its broader applicability beyond technical skills. The findings reveal that CT in Malaysia is defined as a problem-solving methodology emphasizing inclusivity and methodical thinking, as guided by the Malaysian Ministry of Education (MOE). Essential components of CT identified by experts align with MOE's framework and encompass abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation. This approach equips students with skills for a computational world and strengthens their critical thinking. The study concludes that integrating CT by focusing on these key skills can enhance students' problem-solving abilities and support national progress. Limitations include the study's focus on educational technology experts, potentially excluding broader educator perspectives, and variations in CT adaptation across regions. Future research should include diverse educator viewpoints and longitudinal studies to assess CT instruction's long-term impact and effectiveness.

Keywords: Computational thinking, Malaysian educational context, definition, CT components, educational technology experts

1. Introduction

Computational Thinking (CT) has become a crucial skill in modern education, equipping students with essential problem-solving abilities for a digital world. Key processes in CT include abstraction, which simplifies complex problems; automation, which involves creating algorithms and using computational tools; and analysis, which evaluates the effectiveness of solutions (Yadav et al., 2014). The Computational Thinking Scale (CTS) assesses these skills across various contexts, helping educators enhance CT abilities (Tsai et al., 2020). Globally, educational systems are incorporating CT into curricula through programming and coding courses to boost problem-solving skills and prepare students for technology-driven careers (Kafai & Proctor, 2021; Moreno-Leon et al., 2016). Innovative methods like educational robotics and interactive learning environments are also employed to engage students and foster CT development (Isnaini & Budiyanto, 2018; Yadav et al., 2014). In Malaysia, integrating CT is essential for addressing environmental challenges and promoting sustainable development (Abidin et al., 2023). However, challenges persist, particularly in rural areas, and a lack of comprehensive understanding among educators impedes effective CT instruction

(Ung et al., 2019; Anuar et al., 2020; Kutty & Puteh, 2019). Addressing these obstacles is vital for advancing CT in education. The research questions guiding this investigation are: How do educational technology experts define computational thinking in the Malaysian educational context? What do these experts consider to be the essential components of computational thinking in this context?

2. Literature Review

Computational thinking, as originally articulated by Wing (2006, 2008), focuses on the formulation of problems and the development of solutions using computational steps and algorithms. Wing's definition evolved in 2011 to encompass not only problem-solving and system design but also an understanding of human behavior through core computing concepts such as abstraction and automation. This broader perspective highlights CT's relevance across a variety of disciplines and underscores its transformative potential beyond the realm of computer science. Grover and Pea (2013) echoed this sentiment, recognizing CT's potential to impact various fields. Ortiz and Pereira (2020) further emphasized CT's critical role across diverse domains, affirming its importance in fostering a wide range of skills. In the context of Malaysian education, CT is increasingly regarded as a vital 21st-century competence that extends beyond mere coding and programming. This perspective aligns with global views on CT's broad applicability while adapting it to meet local educational needs (Ung et al., 2019). The core components of CT include several fundamental concepts. Abstraction involves simplifying complex problems by concentrating on essential elements and ignoring irrelevant details, which helps in understanding and addressing the core aspects of a problem (Yadav et al., 2014).

Decomposition is the process of breaking down intricate issues into smaller, manageable parts, making it easier to tackle each component systematically (Dagienė & Sentance, 2016; Tsai et al., 2020). Pattern recognition involves identifying similarities and recurring themes within problems, which allows for the application of existing solutions to new challenges (Dagienė & Sentance, 2016). Algorithmic thinking focuses on creating step-by-step procedures to solve problems, fostering structured and logical reasoning (Yadav et al., 2014; Tsai et al., 2020). Evaluation is critical for assessing the effectiveness and efficiency of solutions, involving the testing and refining of algorithms to improve their performance (Tsai et al., 2020). Finally, generalization involves applying learned concepts to new, related problems, thereby enhancing versatility in problem-solving (Tsai et al., 2020). Integrating these components into the Malaysian curriculum is crucial for developing students' problem-solving skills and preparing them for the complexities of a computational world. Research has shown that CT significantly enhances problem-solving abilities across various domains, including STEM fields and programming education (Sholihah & Firdaus, 2023). This underscores CT's pivotal role in cultivating robust problem-solving capabilities within the Malaysian educational landscape, ultimately contributing to students' readiness to face diverse challenges in an increasingly digital age.

3. Methodology

A qualitative research approach was chosen to explore the definition and components of CT in the Malaysian education system, given its effectiveness in capturing complex, nuanced insights (Dorussen et al., 2005). Semi-structured interviews were the primary method of data collection, providing flexibility and depth. This format allowed participants to offer detailed insights and enabled researchers to probe deeper into emerging topics (Creswell & Plano, 2017). Participants were selected through purposive sampling, focusing on individuals with at least 10 years of experience and expertise in CT. This ensured the relevance and depth of the collected insights. Data collection continued until saturation was achieved, indicating no new significant information was emerging (Coyne, 1997). The interviews addressed two main areas: the definition of CT and its core components in the Malaysian context. Data were analyzed using Burnard's (1991) framework (Table 1) to identify recurring themes and patterns. We acknowledged that research findings are subject to interpretation and may vary based on the researcher, participants, or context (Cohen, Manion, & Morrison, 2000). This perspective informed our analysis, emphasizing the subjectivity and potential for diverse interpretations in qualitative research.

Table 1. *Steps of analysis.*

Stage	Description
Data Familiarization	The interview transcripts were read multiple times to fully understand the content.
Open Coding	Significant phrases or sentences were identified and coded.
Category Formation	The codes were grouped into broader categories representing underlying themes.
Reviewing Categories	Categories were reviewed and refined to ensure they accurately represented the data.
Developing Themes	The refined categories were synthesized into overarching themes that captured the essence of the respondents' perspectives.
Final Synthesis and Reporting	A coherent narrative was constructed, integrating the identified themes.

4. Result

The interview protocol was designed to explore how Computational Thinking (CT) is perceived and defined across different educational contexts in Malaysia and to identify the core elements that experts believe should be emphasized in CT education. The respondents, all seasoned professionals, include four females and one male, with their years of service ranging from 11 to 18 years. Their expertise covers a broad spectrum of educational fields, with a notable focus on computational thinking. This diverse range of backgrounds ensures a comprehensive understanding of CT's role and significance in Malaysian education.

4.1 Definition of CT in the Malaysian Educational context.

The data analysis was refined into two broader themes that encapsulate the overall definitions and perspectives on computational thinking within the Malaysian educational context.

Theme 1: Adherence to MOE’s Definition of Computational Thinking
The first theme identified from the interview data highlights the consensus among experts that the definition of CT provided by the Malaysian Ministry of Education (MOE) serves as a guiding framework for the education system.

- The educational system must adhere to the six elements of CT as defined by the MOE, though with adjustments to fit the local educational context. This perspective reflects a strong alignment with national policies, recognizing the need for localization in implementation. (Respondent 1)
- I agreed with MOE's definition, acknowledging its direct applicability within the Malaysian education system. Computational thinking involves a systematic approach to problem-solving, including decomposition, abstraction, algorithm development, pattern recognition, and logical evaluation. This step-by-step method enhances students' efficiency in solving problems. (Respondent 2)
- I further supported this definition, emphasizing its adequacy in addressing the diverse educational backgrounds in Malaysia. Computational Thinking (CT) is not perceived as a new subject but rather as an element integrated across various disciplines (Respondent 3).
- CT can be defined as a general problem-solving skill, integral to various subjects and

adaptable to Malaysia's diverse educational contexts. (Respondent 5)

Theme 2: Localization and Adaptation of Computational Thinking
Another prominent theme is the need for localization and adaptation of the global concept of CT to fit the unique circumstances of Malaysian education.

- While the global definition of CT often emphasizes coding, programming, and mathematics, the Malaysian context requires a more generalized approach focused on problem-solving. This need arises from the disparity in infrastructure and resources across different schools. (Respondent 1)
- Initially derived from computer science, CT can be adapted to various subjects beyond its original scope, aligning with the broader educational landscape in Malaysia (Respondent 4).
- We must adapt CT to address both teaching and learning challenges, suggesting that the definition should encompass the needs of both teachers and students. (Respondent 5)

The analysis of the interview data reveals that educational technology experts in Malaysia define computational thinking as a versatile, problem-solving skill that is essential across various educational contexts. While adhering to the definition provided by the Ministry of Education, they emphasize the importance of localizing and adapting CT to the unique conditions of Malaysian schools. This includes moving beyond coding and programming to ensure that all students can benefit from CT, regardless of their access to resources.

4.2 The essential components of CT in Malaysian educational context.

The interview data were synthesized into two overarching themes that encapsulate the experts' perspectives on the essential components of CT.

Theme 1: Consensus on Core Components
The majority of experts expressed agreement on the six core components of computational thinking as defined by the Malaysian Ministry of Education (MOE): abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation.

- The MOE defines six essential components of CT, and these definitions facilitate understanding and implementation at the school level. This perspective emphasizes the importance of adhering to the MOE's definitions to align with Malaysia’s educational goals. (Respondent 2)
- There is significant value of all six components, noting that each element contributes to developing a robust CT skill set. Each component of CT, as defined by the MOE, has its unique strengths and applications, contributing to a comprehensive CT skill set. This acknowledgment underscores the value of incorporating all six components into educational practices. (Respondent 4)

Theme 2: Additional Importance of Logical Reasoning and Evaluation
Several experts underscored the significance of including logical reasoning and evaluation as essential components of CT, particularly in the Malaysian educational context.

- Previous studies often overlook logical reasoning and evaluation, these skills are crucial and distinct from the other components. Logical reasoning involves cause-and-effect thinking, while evaluation focuses on reviewing and assessing completed tasks. This view aligns with the MOE’s comprehensive approach to CT. (Respondent 1)
- The Malaysian CT framework builds on globally recognized elements such as abstraction, decomposition, pattern recognition, and algorithms but adds logical reasoning and evaluation to strengthen the CT skills within the Malaysian educational context. This addition reflects an adaptation to local needs and challenges. (Respondent 3)
- While abstraction, decomposition, pattern recognition, and algorithms are

foundational, logical reasoning and evaluation are necessary for achieving effective problem-solving in all educational fields. (Respondent 5)

The analysis of the interview data reveals a broad consensus among educational technology experts regarding the essential components of computational thinking in the Malaysian educational context. The experts agree on the six core components defined by the Ministry of Education: abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation. They emphasize the importance of including logical reasoning and evaluation as integral elements that enhance problem-solving skills. The findings suggest a balanced approach that integrates both global and local perspectives, ensuring that the CT framework effectively supports educational goals in Malaysia.

5. Discussion

In the Malaysian educational context, educational technology experts defined CT as a systematic approach to problem-solving that needs to be tailored to fit the local educational landscape, ensuring that all students can benefit from it, not just those with access to coding and programming resources. Ung et al. (2019) emphasized that this inclusive approach ensures CT is accessible and relevant to all students, nurturing a problem-solving mindset and critical thinking skills applicable across various domains. Ye et al. (2022) documented CT's evolution into a broader literacy, connecting personal expression with other literacy areas, underscoring its role as a vital 21st-century competence. Both global studies and the Malaysian context highlight the core components of CT: abstraction, decomposition, pattern recognition, and algorithms. In addition to these foundational elements, Malaysian educational experts emphasize two additional components: logical reasoning and evaluation. These components are integral to fostering a deeper comprehension of problem structures and refining problem-solving approaches (Ung et al., 2019). This comprehensive approach not only prepares students for a computational world but also enhances critical thinking skills relevant across various fields. By fostering computational thinking from an early age, Malaysian schools can prepare students to be adaptable problem-solvers and lifelong learners, contributing to national development in the digital age (Anuar et al., 2020).

In conclusion, incorporating computational thinking into Malaysian education by focusing on key skills; abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation helps students develop flexible problem-solving abilities and critical thinking, equipping them to tackle future challenges and support national progress in the digital era. This study's limitation is its focus on educational technology experts, which may not fully represent the perspectives of all educators within Malaysia. Furthermore, CT adaptation may vary across regions and institutions, affecting implementation consistency. Future research should explore a broader range of educators' viewpoints and conduct longitudinal studies to evaluate CT instruction's long-term impact on student outcomes and pedagogical effectiveness. Investigating the challenges and successes of CT implementation in diverse educational environments could provide valuable insights for refining CT curricula and teaching strategies.

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