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Development and Validation of a Problem-Solving Instrument (Multiple-Choice Questions) for Computational Thinking Among Trainee Teachers in the Klang Valley, Malaysia

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Abstract: In the 21st century, the integration of computational thinking (CT) into education has become crucial, enhancing students' abilities to address complex problems through systematic and innovative approaches. Malaysia has recognized this need by embedding CT into its national curriculum, emphasizing key components such as abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation. However, challenges remain in defining CT consistently and assessing its integration effectively, particularly among trainee teachers. This study aims to develop a robust multiple-choice question (MCQ) assessment tool to measure CT skills among trainee teachers in Malaysia. Utilizing a mixed-methods approach, the research begins with qualitative insights from educational technology experts to refine CT definitions and components. This informs the subsequent quantitative phase, involving the development and validation of the MCQ tool. Key objectives include evaluating content validity, difficulty and discrimination indices, and construct validity. The study's outcomes will provide a standardized measure of CT, guiding educational strategies and enhancing teacher training programs to better prepare educators for the digital age. The research underscores the importance of a universal CT assessment tool tailored to Malaysia's educational context, promoting consistent and equitable development of essential 21st-century skills.

Keywords: Computational thinking, teacher trainee, assessment tool, educational technology, mixed-method research

1. Introduction

In the 21st century, computational thinking (CT) and higher-order thinking skills (HOTS) have become essential in modern education, enhancing students' abilities to solve complex problems and design systems. CT, as defined by Wing (2006), focuses on systematic problem-solving rooted in computer science, while HOTS involve broader cognitive processes such as critical thinking and evaluation (Ibrahim et al., 2015). The rise of technology demands innovative solutions, making both CT and HOTS critical but distinct in application. CT encompasses skills like decomposition, pattern recognition, abstraction, algorithms, and logical reasoning (Tsai et al., 2020). Recognizing CT's importance, Malaysia integrated it into its education system, with the Ministry of Education introducing CT skills into the national curriculum for primary and secondary levels (MOE, 2016). Subjects like Asas Sains Komputer (ASK) and Computer Science embed these skills at the secondary level (Yadav et al., 2014). Effective CT teaching requires educators equipped with these skills, emphasizing the need for appropriate assessment tools (Mon et al., 2019). Globally, various CT assessment tools exist (Chen et al., 2017; Kang et al., 2022), but Malaysia needs a culturally and contextually relevant tool aligned with its national curriculum (Ung et al., 2021). The development and validation of multiple-choice questions (MCQs) for CT assessment among trainee teachers in the Klang

Valley are crucial. MCQs offer a practical and scalable method to evaluate CT dimensions like abstraction, decomposition, and algorithmic thinking (Palmer & Devitt, 2007). They provide consistent assessment and help identify gaps in trainee teachers' CT skills, aiding targeted instructional interventions (Grainger et al., 2018). A standardized MCQ-based instrument would align with Malaysia's educational goals, ensuring that trainee teachers are well-prepared to foster innovation, creativity, and critical thinking in the digital era.

2. Problem Statement

Grover and Pia (2013) noted the absence of a universally accepted definition of computational thinking (CT) skills, though core computer science concepts are deemed essential for students. In Malaysia, CT is defined as universal problem-solving skills, primarily taught in Basic Computer Science (primary) and Computer Science (secondary) subjects (MOE, 2016). However, a clearer definition of CT is needed to ensure consistent application across all subjects, aligning with Malaysia's educational goals (Ezeamuzie & Leung, 2021). In-depth research is essential to clarify CT's definition and validate its components within Malaysia's context, facilitating the development of a standard assessment tool. A significant gap exists due to the lack of a universal CT assessment framework, exacerbated by limited studies, time constraints, and an exam-focused education system (Zaharin et al., 2018). Teachers' readiness and competency in CT skills are major challenges (Saidin et al., 2021), and currently, there are no specific tools to assess these skills in Malaysia (Ung et al., 2018). This lack of standardized assessments hampers teachers' professional development and consistent support in CT integration (Markandan et al., 2022). Therefore, developing a valid and reliable CT assessment tool for trainee teachers is critical for effectively integrating these skills into Malaysia's education system (Kong & Abelson, 2019).

3. Research Objective and Research Question

This research aims to develop a multiple-choice question (MCQ) assessment tool designed to effectively measure computational thinking (CT) among trainee teachers.
Objective 1: Elaborate and validate a clear and meaningful definition of computational thinking components from the perspective of educational technology experts in Malaysia.

- RQ1: How do educational technology experts in Malaysia describe and apply the definition of computational thinking proposed by the Malaysian Ministry of Education (2016)?
- RQ2: Is abstraction, decomposition, pattern recognition, algorithms, logical reasoning, and evaluation suitable components of computational thinking for the Malaysian educational landscape from the perspective of educational technology experts?

Objective 2: Develop a standard and universal assessment tool (multiple-choice questions) for measuring computational thinking among trainee teachers in Malaysia.

- RQ3: Does the developed computational thinking assessment tool (multiple-choice questions) have high content validity based on the evaluation of educational technology experts?

Objective 3: Measure the difficulty index and discrimination index of the CT assessment tool to evaluate computational thinking among trainee teachers in Malaysia.

- RQ4: What are the difficulty index and discrimination index for each item in the assessment tool for measuring computational thinking among trainee teachers in Malaysia?

Objective 4: Validate the developed assessment tool that measures computational thinking among trainee teachers in Malaysia.

- RQ5: What evidence supports the internal consistency of each item in the assessment tool for measuring computational thinking among trainee teachers in

Malaysia?

- RQ6: What evidence supports the construct validity of each item in the assessment tool for measuring computational thinking among trainee teachers in Malaysia?

4. Importance of Study and Research Limitations

The development of a computational thinking (CT) assessment tool is crucial for advancing Malaysia's education system, involving key stakeholders like the government, education policymakers, curriculum developers, educational institutions, and teacher training programs. The Malaysian government plays a central role by planning, supporting, and monitoring the tool's development, ensuring the education system meets 21st-century demands. This tool is vital for policymakers to design effective education policies and allocate resources strategically. Educational institutions and teacher training programs use the assessment tool to evaluate and improve CT integration in their curricula, enabling targeted improvements. Trainee teachers, the primary beneficiaries, gain from this focus on CT skills, which are essential for the digital age. The tool helps them identify strengths and weaknesses, enhancing their problem-solving abilities and preparing them for future teaching roles.

This mixed-methods study on Educational Technology aims to develop an effective assessment tool for measuring computational thinking among trainee teachers in the Klang Valley, Malaysia. It combines qualitative insights from experts in Malaysian education, gathered through purposive sampling and online meetings, with quantitative data from a stratified random sample of 576 trainee teachers in the region. While the study is limited by its focus on the central zone, due to cost, resource, and time constraints, which may affect the generalizability of its findings to other regions in Malaysia, it offers valuable contributions to improving the assessment of computational thinking skills, potentially enhancing the quality of teacher education in the country.

5. Methodology

The research employs a mixed-methods approach using an exploratory sequential design, combining qualitative, quantitative, and document analysis methods to provide a comprehensive understanding of the research problem. Initially, qualitative data collection and analysis precede the quantitative phase, involving interviews and document reviews to develop initial constructs for the assessment tool. The qualitative findings then inform the quantitative phase, where the preliminary assessment tool is administered to a larger sample and analyzed using statistical methods like factor analysis to assess its reliability and validity. The study is conducted in Malaysia, focusing on 27 Teacher Education Institutes (IPGs) and 7 public universities offering education programs, targeting a population of 28,496 trainee teachers. For the qualitative study, 10-12 educational technology experts are selected through purposive sampling, while the quantitative study employs cluster sampling followed by stratified random sampling to select a sample size of 384, with an additional 192 samples to account for non-response, totaling 576 participants. Data collection includes online focus group discussions for qualitative data, analyzed using NVivo software, and the developed assessment tool for quantitative data, analyzed using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to ensure its validity and reliability. The integration of findings from both phases refines the assessment tool, making it robust and comprehensive.

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