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Development of a computational thinking assessment tool for lower secondary students in Malaysia

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Abstract: The rise of computational thinking (CT) inclusion in education systems across the world has prompted the needs to effectively measure the computational skills for various educational level, i.e. from early childhood, elementary, secondary (K-12 education) up to adult learners. In this paper, the essence of a research proposal is presented, which focuses on developing and designing an instrument suitable for Malaysian adolescent (i.e. secondary school level students) context. The paper aimed at outlining the research objectives, and limitations and the suggested research design. Delphi technique and interview will be deployed during the first phase of the study to obtain consensus from experts identified in the field, followed by the development of the instrument. Next, the instrument will be validated, and later tested with a group of students taking Basics of Computer Science subjects in schools. The research has implication for many stakeholders, mainly for educators involved in teaching the subject in school setting. The development of this instrument would benefit in assessing appropriate CT skills and practice, in the context of Malaysian education. Among the overarching contribution includes advocating CT as another critical 21st century skillset and enhancing individual competency in problem solving.

Keywords: computational thinking, assessment, Delphi technique, instrument validation.

1. Introduction

Research on computational thinking in education is becoming more substantial due to the awareness among policy makers of the high demand from current digital society, to equip students with 21st century learning skills and its overarching aim to produce digitally literate and competent citizens in the current 4th Industrial Revolution (4th IR) era. Across different countries, curriculum was revamped, and CT framework and its assessment has become one of the priorities in countries which has implemented CT in their educational curriculum. The emerging CT concepts must be added on the new set of competencies required by the new digital generations. All over the world, CT idea has challenged many education scenario in terms of the development of competency models, pre-service teacher education, and integration of CT into curriculum (Kafai, 2016). Many studies have provided evidence on the relevance of CT in both K-12 education and in higher education. Various research suggested the importance of CT to nurture interest and understanding in Science, Technology and Engineering (STEM) courses, for students at different education level. The National Research Council (2010) emphasized the significance of introducing CT to students as early as possible, and assisting them to understand the application of these essential skills. Countries such as England, Finland, South Korea, and Australia have made it compulsory for school children to learn computing or CT (Rich, Jones, Yoshikawa, & Perkins, 2017) .

In Malaysia, the former Prime Minister emphasised the need to integrate CT skills into selected subjects, starting from 2017 with Year 1 primary students (2017) until secondary schools. For secondary schools, the subject called 'Asas Sains Komputer' or basic computing is offered in selected schools for Form 1 to Form 3 students (age range between 13 to 15 years old) which includes the CT elements. In Malaysia, educators who teach the subject are given a short course on CT concept prior to teaching the subject.

The research aimed to contribute in the area of CT assessment, within the scope of lower secondary school level. Besides, it has potentials to facilitate teachers in their measurement of CT at secondary school settings. This effort also could promote better problem-solving ability and innovation amongst lower secondary school students by using computational thinking.

2. Research objectives

The process of developing the right measurement tool for CT skills requires examining and considering existing alternatives and evaluating their effectiveness. The aim requires exploring CT elements or key constructs which is suitable for depiction of problem-solving ability, whilst building a valid and reliable instrument. Hence, the main purpose of the study is to develop an instrument to measure CT skills amongst lower secondary school students in the Malaysian context, besides examining current practices and investigating common issues in assessing CT at lower secondary schools.

2.1 Research questions

1. What are the key constructs of the Computational Thinking (CT) skills instrument that can measure problem solving ability amongst lower secondary students in Malaysian school?
2. What are the content validity related evidences that the items developed are a valid measure of problem-solving ability amongst lower secondary students in Malaysian school?
3. What are the internal consistency related evidences that the items developed are a reliable measure of problem-solving ability amongst lower secondary students in Malaysian school?
4. What are the construct validity related evidences that the items developed are a valid measure of problem-solving ability amongst lower secondary students in Malaysian school?
5. How is CT skills assessment being integrated into current teaching and learning practice, in lower secondary classroom setting?
6. What are the common issues in the assessment of CT, amongst educators in lower secondary school in Malaysia?

2.2 Research limitations

The predicted limitations for this research would be identifying expert panels and getting their cooperation. Also, ensuring their commitment for every round of consultation would remain a challenge given the time constraints. The instrument development process will also possess its own challenge as it will require a lot of iterative process whereby validity will be the most essential aspect to look after, throughout the process.

3. Literature review

3.1 CT Definitions

There is little consensus on a common definition of CT, although there was some agreement on the similarities and differences. Therefore, it is important for everyone to acknowledge the diversity in definitions by different authors and organizations. Among the selected ones from the literature are listed in Table 1 below.

Definitions of Computational Thinking

No	CT Definition	Author
1	"… is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent"	(Wing, 2011)
2	"..an individual's ability to recognize aspects of real-world problems which are appropriate for computational formulation and to evaluate and develop algorithmic solutions to those problems so that the solutions could be operationalized with a computer"	ICILS 2018 (Fraillon, Ainley, Schulz, Friedman, & Duckworth, 2018)
3	(Operational definition of CT). CT is regarded as a problem-solving process which comprises of (but is not limited to) 1) formulating problems in a way that enables us to use a	The International Society for Technology in

	computer and other tools to help solve them; 2) logically organizing and analyzing data; 3) representing data through abstractions such as models and simulations; 4) automating solutions through algorithmic thinking (series of ordered steps); 5) identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources; 6) generalizing and transferring this problem-solving process to a wide variety of problems.	Education (ISTE) and the Computer Science Teachers Association (CSTA), 2011.

3.2 Related theories

Constructivism, as coined by Piaget, indicated that children construct their own knowledge through experience It has remained as the main theory and reference to the history of CT, where the 'constructionism' concept was later introduced (Papert, S., & Harel, 1991) which extends the definition of constructivism. In constructionism, learning process was considered as developing knowledge structures regardless of learning conditions. This "learning by making" implication resonates with the notion of CT. An example of the theoretical framework application is the Computational Thinking Pedagogical Framework (CTPF), developed from constructionism and social-constructivism theories (Kotsopoulos et al., 2017).

Recently, the International Computer and Information Literacy Study (ICILS) introduced measures for students' competency in CT by implementing computer-based tests (Fraillon et al., 2018). In this context, it means new responsibilities for schooling systems in order to offer the opportunity for every child to contribute well in the digital world (Eickelmann, 2019). In Malaysia, prior to the introduction of CT, the Digital Competency Standard (DCS) has been introduced as a measurement tool to assess students' digital competencies, at selected schools (Mohamed Shuhidan, Mohamed Shuhidan, Abu Bakar, & Abd Hakim, 2016). The DCS was based on Ministry of Education ICT skills set, ISTE standards, UNESCO media and Information Literacy Standards (Zainudin & Educational Technology Division, 2016). The initiated DCS program is related to the effort of embedding CT concept into Malaysian primary and secondary education curriculum.

3.3 CT Assessments

From the literature, there are different techniques of assessing CT ability or skills, at different levels of education. Among the well-known ones are the assessment tools related to software ("The Fairy Assessment" in Alice program, Dr Scratch and the popular Scratch by Massachusetts Institute of Technology, a visual programming software, which inculcates CT). Other techniques include Computational Thinking Test or CTt (Román-gonzález, 2015; Román-González, Pérez-González, & Jiménez-Fernández, 2017), Bebras (or Beaver) Challenge, competition-based questionnaire (Dagienė & Stupurienė, 2016; Liz, Araujo, Andrade, & Guerrero, 2019), multiple evaluation approach, online assessment tool (Computational Thinking Pattern Analysis, or CTPA (Ioannidou, Bennett, & Repenning, 2011), Real Time Evaluation and Assessment of Computational Thinking, or REACT (Koh, Basawapatna, Nickerson, & Repenning, 2014), CT Self Efficacy scale, and using convergence (combination of many assessment method), among others. The variety of assessment reflected different contextual requirement and understanding CT concepts, CT elements and are based on their educational curriculum objectives especially in computing or information technology related subjects.

4. Proposed methodology

The researcher will apply the sequential explanatory design, which will involve a quantitative, followed by a qualitative phase (Ivankova, Creswell, & Stick, 2006). In the first phase, quantitative data will be collected via Delphi technique. During the first phase, panel of experts will be invited and consulted through a series of questionnaire (and follow up for few rounds) to get a consensus on the constructs to be included in the instrument development for CT skills for lower secondary school students. The experts consist of related national agency officers, CT trainers, expert teachers and subject matter experts from the industry. In the second phase, the points taken from the Delphi consensus will be triangulated with interviews, where different panelists giving their opinions on certain criteria, which

emerge from the Delphi rounds, in order to better understand why certain construct, tested in the first phase, were significant or not for measuring students' CT skills, at lower secondary schools in Malaysia.

5. Proposed contribution

The study has its own strength and significance as it aims to develop a measurement tool for CT skills in the Malaysian context. The study would contribute significantly by focusing on the assessment of CT skills for lower secondary school students.

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