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Need Analysis: The Development of Biology – CT Training Module for Matriculation Educators

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Abstract: This study aims to analyse the need for the development of a Biology – Computational Thinking (CT) training module for integrating computational thinking skills into Biology lessonsamong matriculation educators. The module will be developed utilising a design and developmental research (DDR) approach. This article discusses the need analysis phase of DDR. This research uses a qualitative methodology using semi-structured email interviews. To respond to the questions, four university educators with backgrounds in biology or computer science were chosen using the purposive sampling approach. The findings revealed a need for the development of the Biology - CT module in order to assist matriculation biology educators in acquiring the necessary competencies in CT. Experts advised educators to understand the four basic ideas of CT, namely decomposition, pattern recognition, abstraction, and algorithm, through project-based learning, problem-based learning, and inquiry-based learning. According to experts, both unplugged and plugged-in activities are equally significant in CT learning and may be assessed through observations, assignments, presentations, and reflections. The results of this study are important to ensure that the design and development of a training module for matriculation biology educator are implemented and have a positive impact on increasing the programming literacy level among secondary school children.

Keywords: Computational Thinking, training module, semi-structured email interview.

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INTRODUCTION

Malaysian Education Development Plans (2013-2025), which include matriculation students, place an emphasis on 21st-century learning skills like computational thinking in order to prepare these students for global competition. Computational thinking (CT) was coined by Seymour Papert in 1980, but in a different context than what is commonly understood today. Papert views CT as the product of his constructionist approach to education, in which emotional and social factors are given equal weight to technical ones. CT can help students become more analytical and rational thinkers (Lodi & Martini, 2021). CT is becoming mainstream and widespread, involving multiple disciplines, including Science, Technology, Engineering and Mathematics (STEM). The integration of CT in STEM education including Biology subject in matriculation colleges has the potential to improve motivation (Angeli & Giannakos, 2020; Grover et al., 2020), increase engagement in the classroom (Liao et al., 2022), and help educators to prepare the students for the future by encouraging creativity and problem-solving skills (Fessakis et al., 2018). However, transforming our education so that every learner is CT competent requires educators' dedication and deliberate transformation (Barr & Stephenson, 2011). CT is still new and most educators including matriculation educators have not been trained in CT content and pedagogy. They need in-service training to overcome emotional and knowledge hurdles so that they can integrate CT into their classes (Kaya et al., 2019; Rich et al., 2021; Simmonds et al., 2019). Modules can assist educators training and come up with new teaching strategies to incorporate CT concepts, activities and evaluation techniques into their lesson.

LITERATURE REVIEW

Computational Thinking

Computational thinking (CT) is a fundamental 21st-century skill (Güven & Gulbahar, 2020) that involves problem formulation, problem-solving, and scientific reasoning (Wing, 2006). Wing presented the idea of CTs' integration in education, saying that CT is not the act of thinking like a computer but rather a way of problem-solving that employs computer science principles and ideas. CT is a basic competency that all literate individuals must achieve in compulsory school, along with reading, writing, and arithmetic. Additionally, CT can have a greater impact by explicitly educating students on metacognitive techniques (Yadav et al., 2022), which are crucial for academic success (Romainor et al., 2018; Tang et al., 2020; Yang et al., 2021).

CT Concepts

The concepts of CT as proposed by Computer at School (CAS), United Kingdom (i.e., decomposition, pattern recognition, abstraction, algorithmic thinking) (Csizmadia et al., 2015), have a strong relationship with STEM education in Malaysia. The same concept was proposed in the Standard Document for Curriculum and Assessment (DSKP) by Kementerian Pendidikan Malaysia (KPM) in 2017. CT is related to STEM disciplines and will be at the forefront of STEM innovation (Love et al., 2022; Pewkam & Chamrat, 2022; Yin et al., 2022). CT and STEM education, both emphasise the twenty-first-century skills such as problem- solving, logical thinking, communication, critical thinking, and media literacy (Braun & Huwer, 2022; Tripon, 2022). In this respect, it can be said that integrating CT concepts in STEM education, provides better learning of STEM domains (Dagienė & Sentence, 2016; García-Peñalvo & Mendes, 2018; Sengupta et al., 2013).

CT Teaching Strategies

Educators use a wide range of ways to incorporate CT into their lessons, including project-based learning, problem-based learning, collaborative learning, game-based learning, teacher-centered learning, scaffolding techniques, and story-telling (Hsu et al., 2018). In addition, discovery learning, experiential learning, social learning, situated learning (Passey et al., 2018), as well as inquiry-based learning (Sulistiyo & Wijaya, 2020) is also practiced in implementing this CT-based learning and facilitation. However, the methods that are often used in CT-based teachingare a project-based learning, problem-based learning, game-based learning (Hsu et al.,2018) and inquiry-based learning (Kusnan et al., 2020; Saad, 2020; Taengkasem et al., 2020; Waterman et al., 2020). These four methods are also methods that are often used in Biology teaching (Arboleya-García & Miralles, 2022; Berie et al., 2022; Burks, 2022; Gya & Bjune, 2021; Marthaliakirana et al., 2022; Ristanto et al., 2022; Ruhl & Sanders, 2022; Shirinzada Nijat, 2022; Villalba et al., 2022; Webster et al., 2022) and are appropriately applied to the development of Biology training modules based on CT skills.

CT activities

CT activities can be implemented either through the use of digital equipment (plugged-in) (Connolly et al., 2021; Janne Fagerlund et al., 2021; Fidai et al., 2020; Kastner-Hauler et al., 2022; Sigayret et al., 2022), without digital equipment (unplugged) (Lim & Chen, 2021; Peel et al., 2022; Yang et al., 2022) or through a combination of both (Bati, 2022; Polat & Yilmaz, 2022; Samri et al., 2021; Sun et al., 2022). Unplugged activities provide an alternative to the implementation of teaching involving CT without having to rely on programming activities that involve the use of computers and only focus on CT ideas and techniques (Brackmann et al., 2017; Rodriguez et al., 2016) whereas, plugged-in activities involve the use of programming applications, games and robotics kits. In general, both activities have helped students understand CT techniques more easily (Bati, 2022; Moreno-Leon et al., 2018; Samri et al., 2021) improving achievement (Basu et al., 2017; Rodriguez et al., 2016), mastering creative thinking skills, working systematically and being able to collaborate in solving problems (Resnick, 2019).

Evaluation of CT activities

Evaluation of CT activities involved questionnaire instruments (Hsieh et al., 2022; Youjun & Xiaomei, 2022; Zapata-Caceres et al., 2020), pre- and post-test (Boya-Lara et al., 2022; Chevalier et al., 2022; Weng et al., 2022), portfolio (Gadanidis et al., 2018; Lui et al., 2020), interviews (Litts et al., 2020; Weintrop et al., 2021), rubric (Çakiroğlu & Çevik, 2022; Espinal & Magana, 2022; Yeni et al., 2022), artifacts (Liu & Xia, 2021; Wu & Yang, 2022), projects (Chang & Lin, 2022; Christian et al., 2021), classroom observations(Bonner et al., 2021; Ghani et al., 2022; Maitz et al., 2022) and also reflection reports (Addone et al., 2021; Shahin et al., 2022; Skuratowicz et al., 2021).

Figure 1 summarises the concepts, teaching strategies, learning activities, and evaluation technique widely employed in learning CT.

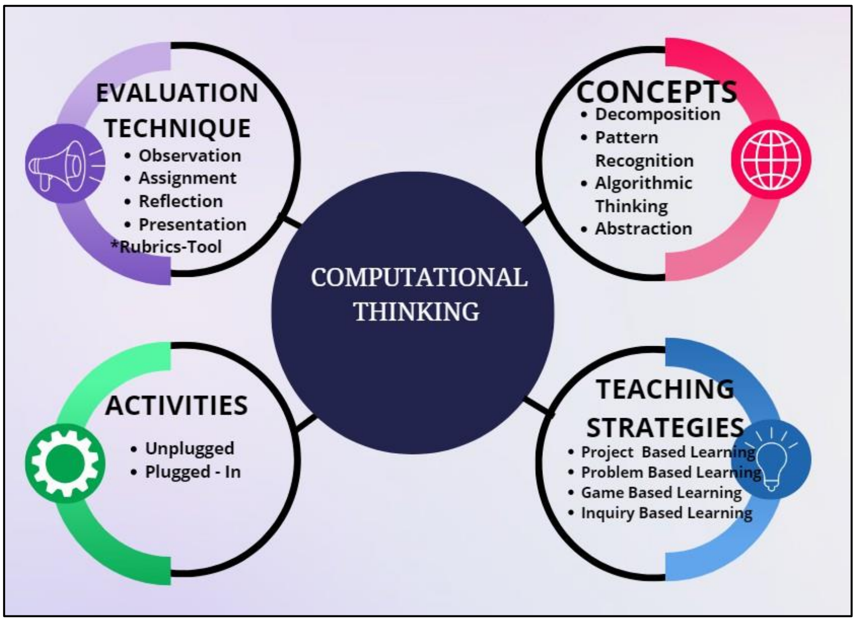

Figure 1: Concepts, Teaching Strategies, Activities and Evaluation technique in CT

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PROBLEM STATEMENT

Numerous studies have focused on the growth of CT professional development for educators across the world (Colclasure et al., 2022; Knie et al., 2022; Mumcu et al., 2022;; Nugent et al., 2022; Yaşar et al., 2022; Nik Hazimin & Hazrati; Ung et al., 2018, 2022; 2019). Therefore, the Ministry of Education (MoE) Malaysia has introduced CT and undertakes various efforts to promote CT to all levels of education in Malaysia. Nonetheless, it can be difficult for educators to assimilate CT knowledge (Angeli & Giannakos, 2020) because they are having issues such as a low understanding level of CT, rate themselves as ignorant, and are not confident in delivering CT- based lessons due to a lack of exposureto CT skills (Ummi Hani & Siti Fatimah, 2020). They believe CT is linked to coding, that it requires digital technology to conduct the lesson, and that one must have computing abilities to learn CT (Ung et al., 2022), but they rarely, if ever, have the opportunity to participate in any kind of formal training or workshop related to CT (Nur Nazuha Beevi & Nordin, 2019). Further more, educators are required to make modifications to the existing curriculum (Khasyyatillah & Osman, 2019) and acquire new appropriate instructional strategies (Rich et al., 2020; Thibaut et al., 2018; Yadav et al., 2018) without sufficient resources to guide them (Jekri et al., 2020). This is a concerning situation among Malaysia educators including matriculation educators since they have to guide students for future employability which include CT skills (Cao et al., 2020; Lai & Wong, 2021; Malallah et al., 2020). To overcome these obstacles, it is crucial to ensure that educators have extensive knowledge of CT (Saidin et al., 2021). Thus, the researcher feels the need to conduct a needs analysis involving expert with CT knowledge in the development of a training module for biology educators in matriculation colleges so that they can improve their teaching skills in CT. Developing a high-quality module also requires reaching a consensus amongst experts over the module's component in order to ensure its success. With the existence of this module, biology educators in matriculation colleges can engage in professional development workshops or courses to enhance their teaching skills so they can integrate CT into Biology classes and to be on par with current curriculum developments for the benefit of their practice.

RESEARCH QUESTION

The study is focused on examining and analysing the experts' views on the necessity of developing a training module for biology educators in matriculation colleges. To achieve this aim, the needs analysis tried to answer the following research questions:

1. Is there a need to develop a training module to introduce computational thinking to biology educators in matriculation colleges?
2. Is there a need to improve professionalism in CT among biology educators in Matriculation College?
3. What are the appropriate CT concepts to use in the development of the CT training module for biology educators in matriculation colleges?
4. What are the appropriate teaching strategies to use in the development of the CT training module for biology educators in matriculation colleges?
5. What are the appropriate CT activities to use in the development of the CT training module for the biology lecturer in the matriculation college?
6. What are the appropriate approaches to evaluating CT activities to use in the development of the CT training module for the biology lecturer in matriculation college?

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METHODOLOGY

A qualitative research approach with semi-structured email interview questions was utilised in this need analysis study to investigate the necessity for developing a training module for biology educators at matriculation colleges so that they can integrate computational thinking into their lessons. One significant advantage of the email interview is that it provides a handy and practical option for overcoming geographical hurdles and budgetary issues that impede face-to-face interviews (Hawkins, 2018). The richness and quality of the data obtained via email interviews are considered very similar to those obtained in face-to-face interviews (Ratislavová & Ratislav, 2014). Purposive sampling was used to select four university educators who are also experts in biology or computer science denoted by R1, R2, R3, and R4 in order to identify and seek their perspectives on the need for the training module. The purposive sampling method is used to gain access to "knowledgeable people" who have in - depth knowledge about specific issues, either by virtue of their professional position, power, network access, expertise, or experience (Creswell & Clark, 2018). Email interviews were treated in the same way for coding purposes as other interview transcriptions and documentary material. The data from the email interviews were compiled based on the questionnaire items and inductively analysed using the content analysis technique (Mayring, 2014), since it is one of the qualitative approaches used to summarise textual data (Elo *et al*., 2014).

FINDINGS

In this study, four university lecturers (experts) were email interviewed to gain their perspectives on the need to develop a training module for educators in matriculation colleges on how to integrate CT into biology lessons as well as their opinions on the suitable concepts, teaching strategies, activities, and evaluation techniquesto use in the module. The first research question seeks to identify experts' opinions about the need to develop a training module for computational thinking. All expert agree to the need of developing a training module for educators to learn how to integrate Biology with CT. Concerning the need to promote professionalism in CT among matriculation college biology educators, experts believe that matriculation educators must be proficient and competent in their job while also equipping themselves with key abilities that will help them advance in their careers. Moving on to the third research questions, consensus was reached amongst the experts that teachers needed to have a firm grasp on four essential concepts in CT: decomposition, pattern identification, algorithmic thinking, and abstraction. On the aspects of teaching strategies, majority of the experts agreed that these should include: problem based learning, project based learning and inquiry based learning. Meanwhile, experts agreed that both unplugged and plugged-in CT activity are appropriate for learning CT. Finally, the experts agreed that grading projects, assignments, reflections (reports) and presentations using rubrics (checklists) may be a way to evaluate CT activities. Table 1 summarises expert views on the components of a training module for matriculation biology educators.

Table 1. Expert views on the development of the training module

No.	**Expert Views**	**Experts No.**			
		R1	**R2**	**R3**	**R4**
1.	**Experts views on the need to develop a training module to introduce computational thinking to biology educators in matriculation college.**				
	Agree	√	√	√	√
	Disagree				

2.	**Experts views on the need to improve professionalism in CT among biology educators in matriculation college.**				
	Agree	√	√	√	√
	Disagree				
3.	**Experts views on the appropriate CT concepts to use in the development of the CT training module for biology educators in matriculation college.**				
	Decomposition	√	Not all CT concepts suitable for Biology. Used according to Biological Theme.	√	√
	Pattern Recognition	√		√	√
	Abstraction	√		√	√
	Algorithm	√		√	√
	Logical Reasoning	√			√
	Evaluation	√			
4.	**Experts views on the appropriate teaching strategies to use in the development of the CT training module for biology educators in matriculation college.**				
	Problem Based Learning	√	Educators who teach the subject should be more knowledgeable in integrating CT by choosing an approach according to the topic in the biology course.	√	√
	Project Based Learning	√		√	√
	Inquiry Based Learning	√		√	
	Student Centered Learning			√	
	Study Case			√	
	Contextual Learning			√	
	STEM Learning			√	
	Challenge Based Learning				√
5.	**Experts views on the appropriate CT activities to use in the development of the CT training module for the biology lecturer in the matriculation college.**				
	Unplugged	√		√	√
	Plugged - In	√	√ (Miro, Coogle)	√	√
6.	**Expert views on the appropriate approaches to evaluating CT activities to use in the development of the CT training module for the biology lecturer in matriculation college.**				
	Observation (rubrics)	√	√	√	√
	Assignment (rubrics)	√	√	√	√
	Reflection/ Reports (rubrics)	√	√	√	
	Presentation (rubrics)		√	√	√

DISCUSSIONS

The study of need analysis at the start of this research has given us useful information about how important it is to create a CT training module for educators in matriculation colleges to improve their skills. Within the scope of this study, which looked at how experts felt about CT, it was found that experts saw CT as an important problem-solving skill that matriculation educators must learn. Because of this, it is important to make a training module and a professional development programme for matriculation educators. Even though experts recommend studying the four main CT concepts of decomposition, pattern recognition, abstraction, and algorithm, matriculation educators must be selective in how they use these ideas, since not all concepts need to be used at the same time (Bavera *et al.*, 2020; Çakiroğlu & Çevik, 2022; Tech *et al.*, 2020). The most common way to apply CT is through project-based learning, problem-based learning, and inquiry-based learning because these approaches are student-centered, interactive, and participatory, and they may help students develop their critical and creative thinking skills. (Oyelere *et al.*, 2022; Tikva & Tambouris, 2021). The ideal approach to teach CT, according to experts, is to use both unplugged and plugged-in activities. While plugged-in activities utilising computers and software can further solidify learners' ideas and comprehension of CT, unplugged activities like a treasure hunt and board game can assist learners to obtain a first grasp on CT procedures because because they require possibly the least amount of cognitive demand and technical knowledge (Samri *et al*., 2021; Sigayret *et al*., 2022; Tsarava *et al*., 2017). One of the ways students can visualize and experience the process needed to complete a task is through unplugged experiences. The unplugged activities allow students to situate CT in a real life context (Curzon *et al*., 2014). As utilised in many research, these activities may be evaluated by observation, assignments, reflection, or presentations (Tang *et al*., 2020).This study is significant since it contains in-depth understanding of the elements that training modules could have. Experts' agreement enhances the module's quality and value since they are aware of the essential components that educators must understand.

CONCLUSION

The results of this study supported the need for the development of a Biology - CT training module based on experts' consensus and suggestions during interview sessions. It is expected that this training module could foster the educators' computational thinking skills with its strengths to meet the demand of the 21st-century. This research plays a role as a reference for future research to develop the biology module oriented to the improvement of computational thinking skills.

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