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Synergizing the Integration of Coding and Programming Competencies through Quadruple Helix Model for Malaysian Vocational Education

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Abstract

Vocational college is one of the leading institutions in coding and programming competencies among students. However, the lack of discussions on the stakeholders roles not treated in much detail and cause the limited information for intervention. This paper attempts to explores the integration of coding and programming competencies in Malaysian vocational education through the Quadruple Helix Model, which synergizes the collective efforts of government, industry, and academia. The investigation centres on the pivotal role of computational thinking within vocational training programs, emphasizing how enhanced computational thinking skills can significantly improve students' ability to address assigned programming tasks effectively. The Quadruple Helix framework supports this by facilitating a dynamic interaction among stakeholders, fostering an environment where academic concepts meet practical industry demands. The analysis suggests that embedding advanced coding skills in vocational education is key to preparing students for the technological challenges of the future job market. The outcome of this study indicates a pressing need for vocational training programs to adapt more robust programming training, which aligns well with industry requirements and academic standards, thus ensuring that graduates are well-prepared to contribute to Malaysia's digital economy. This approach not only benefits the immediate educational context but also positions Malaysian vocational education as a critical player in the global digital landscape. Further work is required to be more focus on many types of stakeholder to coding and programming competencies research in education.

Keywords: Coding, Programming, Computational Thinking, Quadruple Helix Model, Vocational Education, Innovation.

Introduction

In the 21st century, the digital revolution has fundamentally transformed the global economic landscape. Technological advancements have rendered digital literacy a critical competency, essential for participation in the contemporary workforce. Among the myriad skills, coding and programming stand out as indispensable, serving as the backbone of the digital infrastructure that drives modern innovation and productivity. The global emphasis on these skills is evident from the rapid expansion of computer science education initiatives across various education systems, ranging from primary to tertiary levels. Countries like the United States, the United Kingdom, and Finland have integrated coding into their national curricula, recognizing its importance in fostering problem-solving abilities, logical thinking, and creativity among students (Resnick, 2018; Hudin, 2023).

The importance of vocational training has been increasingly recognized as a crucial element in developing a workforce adept at navigating the challenges and opportunities of the digital age. This shift mandates a re-evaluation of educational systems to better align with the emerging demands of the workforce. The 2030 Agenda for Sustainable Development and the latest report by UN DESA (2023) expected a significant increase in the number of youth who have relevant skills, including technical and vocational skills for the job market. The integration of coding and programming competencies in vocational education is not merely a local trend but part of a global movement towards enhancing technical education to meet the digital economy's needs (Guo, 2023; Voon et al., 2022). Countries worldwide are innovating their educational frameworks to incorporate practical skills that are directly applicable in the workplace. The World Economic Forum (2024) emphasizes that as digital tools become increasingly integral to all sectors, the ability to understand and manipulate these tools becomes crucial, making vocational education a pivotal battleground for talent cultivation.

Malaysia’s commitment to transforming its vocational education reflects a broader national strategy to strengthen its economic position by harnessing digital technologies. The Malaysian Digital Economy Corporation MDEC (2021), Malaysia is actively upgrading its educational policies to produce a technically skilled workforce capable of supporting its digital economy ambitions. This involves a substantial enhancement of programming and coding training within vocational schools and institutions, aiming to equip students with the skills necessary to excel in a technologically driven marketplace. Development of coding and computational thinking in Malaysia has been geared towards creating an adaptive education system that responds to technological advancements. Computational thinking involves a set of problem-solving skills and techniques that software engineers use to write programs and apps, including decomposition, pattern recognition, abstraction, and algorithms (Wu et al., 2024). By fostering these skills, vocational education not only prepares students for specific technical tasks but also equips them with a mindset to tackle complex problems across various contexts.

The definitions of programming, coding, and computational thinking are often discussed interchangeably but entail distinct concepts. Programming refers to the process of designing and building an executable computer program to accomplish a specific computing result or to perform a particular function (Denning, 2024). It involves writing, testing, debugging, and maintaining the source code of computer programs. Coding, on the other hand, is the act of writing the codes that the computer hardware understands and acts upon (Patel et al., 2022). It is the initial step in the broader discipline of developing software or applications. Computational thinking, as defined by Wing (2014), is a method of problem-solving that teaches individuals to think like a computer scientist when confronted with a problem. This approach is essential not only in computer science but in many other disciplines as well (Lodi & Martini, 2021; Wing, 2008).

Considering these distinctions and the practical requirements of the job market, Malaysian vocational education is increasingly pivoting towards a comprehensive curriculum that integrates these elements into a cohesive learning experience. This is seen through the application of the Quadruple Helix Model, which involves collaboration among four major societal sectors: government, industry, academia, and the community. This model facilitates a multidimensional dialogue and innovation pathway that enriches the educational environment and ensures that the curriculum remains relevant to both current industry standards and future technological developments (Zakaria et al., 2023). The adoption of the Quadruple Helix Model in vocational education in Malaysia represents a strategic approach to leveraging local strengths while incorporating global best practices (Kunwar, 2024). By fostering a synergistic relationship between educational institutions and the pillars of government, industry, and the broader community, Malaysia can create a dynamic ecosystem that promotes continuous learning and adaptation in response to technological advancements. This model not only prepares students for immediate employment but also equips them with the skills to participate in and contribute to the global digital economy.

Thus, the focus of vocational education in Malaysia on programming and coding, supported by an innovative educational model, positions it as a critical component of the national strategy to foster a resilient and adaptable workforce. This approach not only serves the immediate needs of the Malaysian economy but also contributes to the broader global dialogue on the best practices in vocational education in the digital age.

Concept of Coding, Programming and Computational Thinking Skills

The intersection of coding, programming, and computational thinking skills represents a crucial area in today's digitally driven world. While often used interchangeably, these concepts hold distinct meanings and work synergistically to empower individuals with problem-solving abilities applicable across various domains. Computational thinking provides the mental framework for approaching problems in a structured and logical manner (Adorni et al., 2024; Zhang et al., 2023). Coding acts as the tool to translate these thoughts into instructions for the computer (Dwivedi et al., 2024; Parandekar et al., 2023), while programming encompasses the entire process of developing a solution, from conception to execution (Kumar, 2022). Table 1 briefly explains the core concept of computational thinking and programming.

Table 1
Concept of Computational Thinking and Programming

Computational Thinking (ISTE, 2021)	Programming (Harimurti et al., 2019)
Key aspects of CT: **Decomposition**: Breaking down complex problems into smaller, more manageable subproblems. **Pattern Recognition**: Identifying similarities and trends in data to make predictions and generalize solutions. **Abstraction**: Focusing on the essential information while ignoring irrelevant details to create generalizable solutions. **Algorithmic Thinking**: Designing step-by-step procedures (algorithms) to solve problems.	Programming encompasses a broader scope than coding. It involves: **Problem Definition**: Clearly understanding the problem and desired outcome. **Solution Design**: Planning and designing the solution using computational thinking principles. **Coding**: Implementing the solution by writing code. **Testing & Debugging**: Identifying and fixing errors in the code. **Documentation**: Explaining the code and its functionality.

Looking to current research for the past three years, Schwartz et al. (2024) discussed the Kniwwelino Classroom Kit (KCK) to teach Computational Thinking (CT) in primary and secondary schools, which illustrates the potential of the KCK as an effective tool for teaching CT, highlighting its strengths in engaging students and providing a structured learning experience. The findings provide a comprehensive overview of the KCK's role in teaching CT. Passing through to 2023, there are four studies discussing on Coding, Programming and CT skills. Korhonen et al. (2023) examines the integration of programming into the Finnish educational curriculum and the perceptions of teachers regarding to the new of the curriculum. Discussion concludes that while there is a positive outlook towards the integration of programming in the Finnish curriculum, significant challenges remain.

Addressing these challenges through targeted support and professional development is crucial for the successful adoption of programming as an educational innovation. Next study by (Díaz-Lauzurica & Moreno-Salinas, 2023) discusses the integration of Design Thinking methodologies into programming education to improve student engagement and learning outcomes. The findings indicate that integrating Design Thinking into programming education can significantly enhance student engagement and learning outcomes. By fostering a collaborative and creative classroom environment, educators can better prepare students for the demands of the digital age.

Furthermore, the structure and assessment of CT competency been explored by (Lai & Ellefson, 2023). The study providing a robust framework for understanding CT competency. It emphasizes the need for a multidimensional approach in both research and educational practice, advocating for assessments that reflect the complexity of CT skills in real-world contexts. Hence, it also underscores the relevance of CT in the 21st century, highlighting its importance not only in programming but also in general problem-solving across various disciplines. A comprehensive study on the implementation of a Scratch programming course aimed at enhancing students' CT skills in Taiwan been discussed by (Wu et al., 2023). It is understood that structured approach to teaching computational thinking through visual programming languages like Scratch can significantly benefit students' learning experiences. It also emphasizes the importance of motivation, confidence, and anxiety management in the learning process, and it calls for continued exploration of effective teaching strategies in CT education.

Getting into the 2022 tunnel, Pou et al. (2022) discusses the integration of CT and educational robotics within project-based learning (PBL) frameworks in educational settings. The disquisition presents a compelling case for the integration of computational thinking and educational robotics into project-based learning, showcasing its benefits of peer collaboration in learning, which helps students identify concepts, analyse problems, and build relationships with their peers, and noted challenges such as the short duration of sessions and the initial use of rubrics, which limited in-depth analysis, while also addressing the challenges and considerations necessary for successful implementation. Another miles ahead, a comprehensive overview of the current state of research on Computational Thinking (CT) discussed by (Kılıç, 2022). The findings conclude the significant progress has been made in understanding and implementing CT in education, continued efforts are needed to refine teaching practices, develop effective assessment tools, and ensure that CT is integrated into educational frameworks at all levels. Thus, it is also highlighting both the advancements and the challenges that lie ahead in this evolving field.

Meanwhile, Park & Shin (2022) explore the implementation and evaluation of educational materials designed to teach text processing using a block-based programming language, specifically targeting K-12 students. The study highlights the importance of adapting educational materials to suit the learning capabilities of K-12 students while also addressing the challenges they may face. It advocates for the use of engaging, hands-on programming experiences to foster interest and understanding in text processing, natural language processing (NLP) and artificial intelligence (AI). In the end, Northrup et al. (2022) addresses the complexities and challenges associated with implementing a new computer science (CS) curriculum in rural areas in the United States. The study wrapped up with a conclusion to provides a comprehensive examination of the challenges faced by rural educators in implementing a new computer science curriculum, emphasizing the need for integrated approaches and effective professional development to enhance educational outcomes in these regions. According to the study’s findings, it presents a holistic view of the current state of coding, programming, and CT education, outlining the challenges and proposing actionable solutions to enhance learning outcomes.

Quadruple Helix Model Expectations

The Quadruple Helix Model is an advanced framework for innovation that extends beyond the traditional Triple Helix Model of university-industry-government relationships (Carayannis & Campbell, 2009; Etzkowitz & Leydesdorff, 1995). It incorporates a fourth helix, representing the media-based and culture-based public and civil society. The model emphasizes the importance of interactions among four sectors; academia, industry, government, and civil society, in fostering innovation and driving the knowledge economy (Kunwar, 2024; Leydesdorff, 2012). The expectations of future innovation in coding, programming, and CT in vocational education in Malaysia involves four pillars of the model consist of government (MOE), academia (vocational college), industry and community.

Participating from every corner may give a big impact in enhancing vocational education in IT programme to meet the industry requirements by synergizing stakeholder efforts to enhance computational thinking skills. Figure 1 shows the future implications of Quadruple Helix Model in coding, programming and computational thinking involving vocational education, specifically in IT programme.

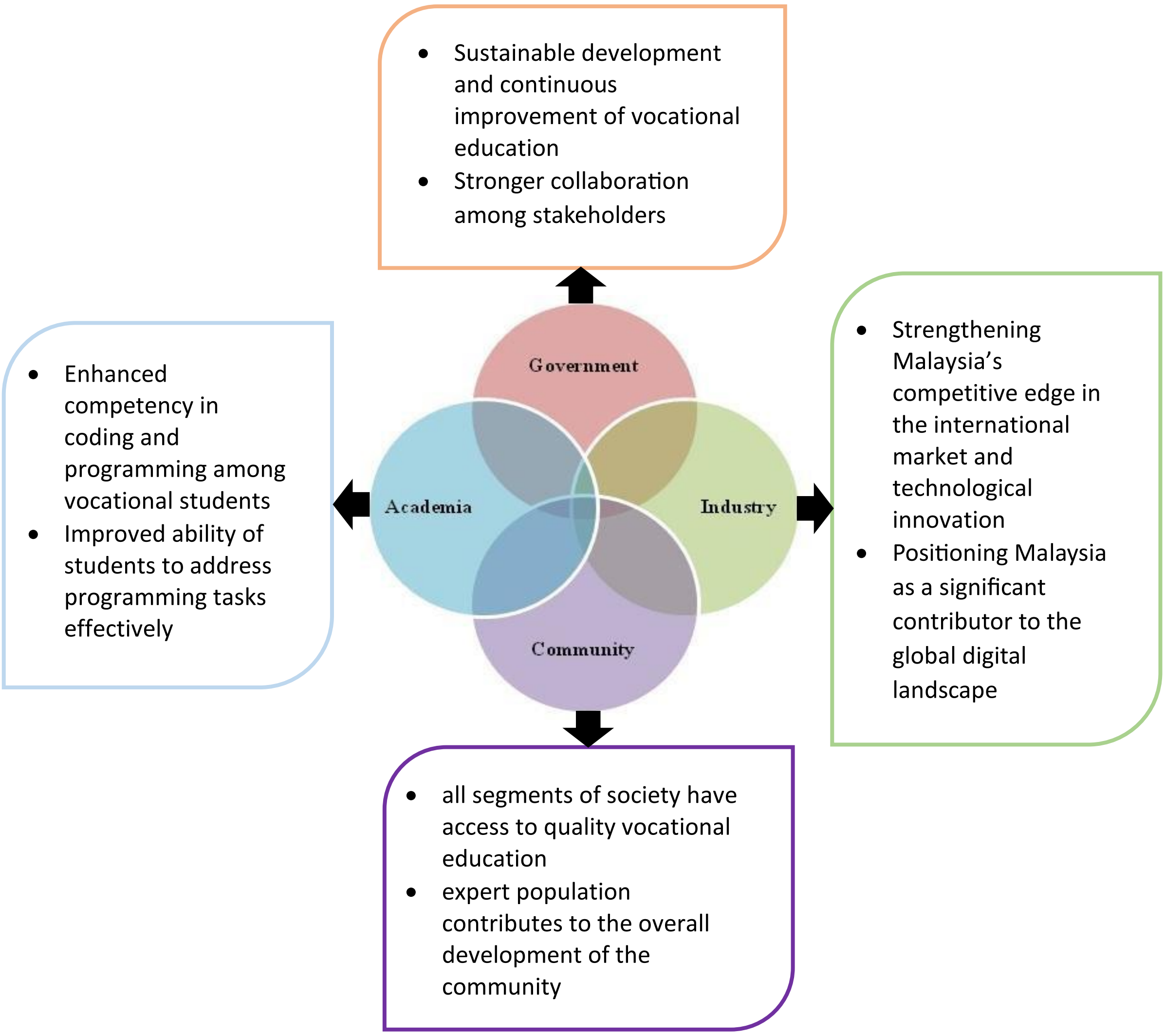

Figure 1. The Quadruple Helix Model for Coding, Programming and Computational Thinking Future Implication

Conclusion

The initiative is set to create a comprehensive impact by integrating the Quadruple Helix Model, which brings together government, industry, academia, and the community. Through this collaboration, the initiative will drive sustainable development and continuous improvement in vocational education, supported by stronger stakeholder engagement. It will enhance Malaysia's competitive edge in the international market by fostering technological innovation, positioning the nation as a significant contributor to the global digital landscape. Academically, students will develop advanced competencies in coding and programming, enabling them to effectively tackle real-world programming challenges. Moreover, the initiative had implication to empower all segments of society have access to quality vocational education, with the expertise cultivated contributing significantly to the overall development of the community. In essence, the Quadruple Helix Model not only improves educational outcomes but also strengthens Malaysia's role in the global economy while fostering inclusive growth and development within the community. A further study with more focus on many types of stakeholder to coding and programming competencies research in education is therefore suggested.

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