ENHANCING SECONDARY SCHOOL STUDENTS' ATTITUDE AND CAREER INTERESTS TOWARDS STEM THROUGH ROBOTICS COMPETITION-BASED LEARNING MODULE

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DOCTOR OF PHILOSOPHY

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A thesis submitted
in fulfilment of the requirements for the degree of Doctor of Philosophy

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2025

DECLARATION

I declare that this thesis entitles Enhancing Secondary School Students' Attitude and Career Interests Towards STEM Through Robotics Competition-based Learning Module is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and not concurrently submitted in candidature of any other degree.

Signature :

Name : PANG YEE JIEA

Date : 20 JANUARY 2025

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature :

Name : PROF. MADYA DR TAY CHOO CHUAN

Date : 18 August 2025

DEDICATION

This project is dedicated to

my beloved husband, Ngan Kwong Song for the unconditional love, sacrifices, and support,

my beloved parents, Pang Hing Pet and Ong Siew Lan, for their love and encouragement;

my lovely kids Ngan Cheer You, Ngan Rynn You, Ngan Joan You, and Ngan Elle You, for their smiles, laughter, and pride in inspiring me to strive for excellence.

ABSTRACT

The persistent decline in secondary school students' enrolment in Science, Technology, Engineering, and Mathematics (STEM), performance, and career interest in STEM fields poses a significant challenge for Malaysia's secondary educational and workforce development goals. Despite national initiatives such as the Malaysia Education Blueprint (2013–2025), the 60:40 Science to Arts Policy, and the National Science, Technology and Innovation Policy (2021–2030), the country continues to face a shortage of STEM-skilled workers. This research addresses these issues by investigating the potential of Robotics Competition-Based Learning (R-CBL) module as an innovative pedagogical intervention to enhance secondary school students' attitudes toward STEM and to foster career interest in related fields. Guided by Constructivist, Constructionist, Social Learning, and Social Cognitive Career Theory (SCCT) perspectives, the study employed a Design and Development Research (DDR) approach structured around the ADDIE instructional model. The research was conducted with Malaysian secondary students participating in the Robot Olympics Malaysia 2019. A mixed-methods design was adopted, combining document analysis, expert validation, pre- and post-surveys using the S-STEM instrument, classroom observations, and focus group interviews. Quantitative data were analysed with SPSS, while qualitative insights were coded thematically to triangulate findings. The results revealed that the R-CBL module significantly improved students' attitudes toward STEM, particularly in terms of motivation, engagement, and confidence. Furthermore, the intervention positively influenced students' perceptions of STEM careers, increasing their interest in pursuing future pathways in engineering, technology, and related disciplines. R-CBL also fostered collaboration, problem-solving, and other 21st-century skills, aligning with national educational priorities and workforce demands. This study contributes theoretically by integrating established learning theories into a robotics competition framework, and practically by demonstrating how R-CBL can bridge the STEM skills gap. The findings provide evidence-based recommendations for policymakers and educators to adopt R-CBL as a scalable, engaging, and effective strategy to strengthen STEM education and STEM career interest among secondary school students.

ABSTRAK

Penurunan enrolmen, prestasi akademik, serta minat kerjaya dalam bidang Sains, Teknologi, Kejuruteraan dan Matematik (STEM) dalam kalangan pelajar sekolah menengah merupakan isu kritikal yang menjejaskan pencapaian sasaran pendidikan negara dan keperluan tenaga kerja berkemahiran tinggi. Walaupun pelbagai dasar telah digariskan, antaranya Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013–2025, Dasar 60:40 Sains kepada Sastera, serta Dasar Sains, Teknologi dan Inovasi Negara (DSTIN) 2021–2030, negara masih belum mencapai tahap keseimbangan yang dihasratkan. Sehubungan itu, kajian ini dijalankan bagi menilai potensi Modul Pembelajaran Berasaskan Pertandingan Robotik (Robotics Competition-Based Learning, R-CBL) sebagai satu pendekatan pedagogi inovatif untuk meningkatkan sikap pelajar terhadap STEM serta menggalakkan kecenderungan mereka terhadap kerjaya dalam bidang ini. Berlandaskan kerangka teori Konstruktivisme, Konstruksionisme, Teori Pembelajaran Sosial, dan Teori Kerjaya Kognitif Sosial (Social Cognitive Career Theory, SCCT), kajian ini menggunakan pendekatan Design and Development Research (DDR) dengan adaptasi model instruksi ADDIE. Subjek kajian melibatkan pelajar sekolah menengah Malaysia yang menyertai Robot Olympics Malaysia 2019. Reka bentuk kaedah campuran diaplikasikan, melibatkan analisis dokumen, pengesahan pakar, soal selidik pra dan pasca menggunakan instrumen S-STEM, pemerhatian berpandukan rubrik, serta temu bual berfokus. Data kuantitatif dianalisis menggunakan perisian SPSS, manakala data kualitatif dianalisis melalui pengekodan tematik untuk tujuan triangulasi. Dapatan kajian menunjukkan bahawa modul pembelajaran R-CBL berkesan dalam meningkatkan motivasi, penglibatan, dan keyakinan pelajar terhadap STEM. Intervensi ini juga mempengaruhi persepsi kerjaya, dengan peningkatan ketara dalam minat terhadap bidang kejuruteraan, teknologi, dan sains gunaan. Selain itu, modul ini turut menyumbang kepada pembangunan kemahiran abad ke-21, termasuk kolaborasi, pemikiran kritis, dan penyelesaian masalah, sejajar dengan aspirasi pendidikan negara. Kajian ini memberikan sumbangan teori melalui pengintegrasian pelbagai teori pembelajaran ke dalam kerangka pertandingan robotik, serta sumbangan praktikal dengan menyediakan bukti empirik bahawa modul R-CBL mampu menjadi strategi berkesan dalam memperkukuh pendidikan STEM dan melahirkan murid sekolah menengah yang minat dalam kerjaya STEM.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

STEM	Science, Technology, Engineering, Mathematics
R-CBL	Robotics Competition-based Learning
MOE	Ministry of Higher Education
PjBL	Project Based Learning
MEB	Malaysia Education Blueprint
UNESCO	United Nations Educational, Scientific and Cultural Organization
OECD	Organisation for Economic Co-operation and Development
KSSM	Kurikulum Standard Sekolah Menengah
SCCT	Social Cognitive Career Theory
ID	Instructional Design
NGT	Nominal Group Technique

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CHAPTER 1

INTRODUCTION

1.1 Introduction

STEM education, encompassing science, technology, engineering, and mathematics, represents a holistic and interdisciplinary approach to teaching and learning. It aims to connect academic knowledge with practical, real-world applications (Bybee, 2013; English, 2016; Moore, 2021; Dare et al. 2021; Ortiz-Revilla et al., 2022). In Malaysia, the Vision 2020 initiative was launched in 1991 with the goal of transforming the nation into a fully industrialized and developed society. A key aim was to foster a scientific and progressive culture, emphasizing the importance of investment in science and innovation for national advancement. This led to the creation of the Malaysia Education Blueprint (MEB) 2013-2025, developed collaboratively by education experts from UNESCO, the World Bank, the OECD, and six local universities. Feedback was collected from various stakeholders, including principals, teachers, parents, students, and community members across Malaysia. The blueprint's objective is to equip Malaysian children with the skills and knowledge necessary for the 21st century while raising educational standards and expectations for the public and parents. Enhancing STEM education is seen as vital for achieving a high-quality education that meets global standards.

In Malaysia, STEM education is emphasized as a strategic priority to prepare students for the demands of a 21st-century workforce. The Malaysia Education Blueprint (MEB) 2013–2025 outlines this commitment clearly: “To transform Malaysia into a high-income nation, we

need to improve student outcomes and ensure our education system meets the needs of the labour market, particularly in Science, Technology, Engineering and Mathematics (STEM) fields" (Ministry of Education Malaysia, 2013, p. E-7). The blueprint identifies the shortage of STEM talent as a national concern and calls for initiatives to improve enrolment and performance in these fields. It proposes to: (i) Increase the number of students in the STEM stream from 45% to 60% (Ministry of Education Malaysia, 2013, p. E-12); (ii) Enhance teacher capabilities in delivering STEM education; (iii) Improve STEM curriculum relevance; and (iv) Encourage partnerships with the private sector to support STEM learning environments. Similarly, Vision 2020, introduced in 1991, set the foundation for a science-oriented and industrialized society: "Malaysia should establish a scientific and progressive society that is innovative and forward-looking" (Government of Malaysia, 1991, para. 3.7.4). This vision influenced the development of STEM-focused educational reforms, including the introduction of the MEB and the 60:40 Science to Arts Policy.

The 60:40 Science to Arts Policy, first articulated by the Higher Education Planning Committee in 1970, emphasized: "To meet the nation's need for scientific and technical manpower, a target ratio of 60% science to 40% arts students was set for upper secondary education" (Ministry of Education Malaysia, 1970, as cited in Ali et al., 2021). However, as stated in the National Science, Technology and Innovation Policy (NSTIP) 2021–2030, Malaysia acknowledges the persistent shortage of STEM talent: "STEM enrolment in schools remains low and uneven. STEM interest must be nurtured from the school level" (MOSTI, 2021, p. 18). The Academy of Sciences Malaysia (ASM) also issued a national-level blueprint, the Science Outlook Report 2017, warning: "There is an alarming trend of declining interest and enrolment in STEM fields in secondary and tertiary education" (ASM, 2017, p. 30). These