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Empowering STEM Interest Through the RBTx Robot Tracer Program Among Primary School Students in the Port Dickson District

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Abstract. This study examined the empowerment of the Science, Technology, Engineering and Mathematics (STEM) interest through the RBTx Robot Tracer Program. The objectives of the study were to: (1) analyze the effect of the RBTx Robot Tracer Program on students' self-efficacy in STEM; (2) assess the role of the program in shaping students' outcome expectations regarding STEM careers; and (3) measure the influence of the program on students' interest and educational goals in STEM. A quantitative approach with a survey design was used to collect data via a questionnaire instrument. Respondents consisted of 154 primary school students who participated in the RBTx Robot Tracer Program organized by Port Dickson Polytechnic. The findings indicated that the level of self-efficacy in robotics and STEM was high with an overall mean of 4.47. Outcome expectations regarding STEM careers were also high with a mean of 4.49, and interest and educational goals in STEM achieved a mean of 4.53. In conclusion, the survey revealed that empowering STEM interest through the RBTx Robot Tracer Program reached a high level. The implication is that the RBTx Robot Tracer Program is an initiative that can inspire students' educational and career goals in the STEM field.

Keywords: Robot Tracer RBTx, Student Self-Efficacy, Outcome Expectations, Career Interest, STEM Education

1. INTRODUCTION

STEM education is emphasized in Malaysia's Education Development Plan (PPPM) 2013–2025. According to Shamsuddin and Noorashikim (2021), the Ministry of Education (MOE) plays a role in strengthening the Science, Technology, Engineering and Mathematics (STEM) education system to attract more students to STEM fields at the school level. One of the STEM subjects taught at primary schools is Design and Technology (RBT). Within the RBT syllabus at the primary level, there are two sections under STEM education: robotics knowledge and computer programming.

Policies that support STEM education include the 60% Science: 40% Arts policy, the National Science, Technology and Innovation Policy (DSTIN), and Vision 2020, as noted in [1]. In line with these policies, the MOE's initiatives aim to strengthen the STEM education system to attract more students, especially at the primary level. STEM integrates four subjects—Science, Technology, Engineering, and Mathematics—into an integrated learning approach [2].

To achieve developed-nation status, STEM education must be more attractive to increase students' interest in STEM. STEM helps students develop their thinking through practical activities, allowing them to design projects and solve real-world problems. Additionally, STEM cultivates scientific attitudes and fosters critical and creative thinking. Teachers need to be proficient in STEM approaches, which can be applied in teaching and learning. The STEM approach applies STEM knowledge, skills and values to solve problems in daily life, community and the environment.

At the higher education level, polytechnic offers an elective course called Embedded Robotics as part of diploma studies. The course introduces mobile robots and embedded systems from introductory to intermediate levels. It is divided into three parts: embedded systems, mobile robots, and mobile robot applications. These parts are important for students to master the steps required to build a complete robotic system. Through this course, students learn about robotics from its origins to current Industry 4.0–based robotic technologies. Embedded Robotics offered at the Polytechnic is a relevant course in facing the current industrial revolution. Knowledge of robotics and digital technologies serves as a platform to expose students at various schooling levels and to complement teaching and learning processes.

Following discussions about the growth of robotics-based education, collaboration occurred between schools and the Polytechnic. The partnership between the Polytechnic and local schools, government and private agencies in Port Dickson has long been established in many areas. This includes advisory and consultancy services in technical and non-technical fields for community development programs, community service operations, participation in official events organized by the state government and the Polytechnic, and more. These collaborative activities align with the Polytechnic's requirement that its staff contribute to the external community, allowing them to share expertise across fields.

As a result of discussions between representatives of Port Dickson Polytechnic and local schools in the Port Dickson District, a community service program titled "Sharing Knowledge and Expertise: RBTx Robot Tracer" was proposed for primary school students interested in learning about robotics, particularly Robot Tracer RBTx. The objectives of the program were to disseminate robotics-related skills and knowledge to primary students, provide hands-on experience with Robot Tracer RBTx, enhance students' soft skills, foster interest in STEM fields, and strengthen collaboration between schools and the Polytechnic.

1.1 Problem Statement

An emphasizes that STEM education places great importance on Higher Order Thinking Skills (HOTS) [3]. These components are believed to produce a young generation capable of solving various problems through communication, teamwork, creativity and critical thinking. Facing future challenges, especially in Industry 4.0 and within VUCA (volatile, uncertain, complex and ambiguous) conditions, will influence youth mindsets and environments. Attracting students to master STEM remains difficult. To become a developed nation, we need resilient young people who are not only technology users but also contributors who create new technologies.

The Ministry of Education's annual report showed that only 47.18% of primary-level students nationwide chose STEM-related fields [4]. Of these STEM students, 26.6% selected Technical and Vocational Education and Training (TVET), while 20.51% chose pure science streams. This situation is worrying and could hinder national development. Therefore, the government proposed additional initiatives to reach a target of 60% STEM enrollment by 2030 to ensure sufficient STEM talent in line with the United Nations' Sustainable Development Goals (SDG) for 2030.

Despite various initiatives, the number of students choosing STEM in Malaysia remains unsatisfactory [5]. Perceptions that STEM subjects are difficult and less relevant, as well as a lack of exposure to real-world applications, contribute to this problem [6]. Furthermore, insufficient involvement in hands-on activities and project-based learning makes STEM learning less engaging [7]. Therefore, programs like Robot Tracer RBTx are needed to address these challenges by providing practical platforms that can increase students' interest and confidence in STEM and open up future career opportunities.

The integration of STEM education into the Malaysian curriculum faces various challenges, which also affect students' interest in this field [8]. Data shows that students' interest in science has declined significantly, from 66.7% in 2019 to only 40% in 2022, as reported in the *Public Awareness of Science, Technology, and Innovation (STI) Malaysia 2022* study [9]. This indicates that students' interest in STEM has not yet reached a satisfactory level [10]. Therefore, programs such as the RBTx Tracer Robot are needed to address these challenges by providing a practical platform that can enhance students' interest and confidence in STEM, as well as open up future career opportunities for them.

All stakeholders should nurture and instill interest in STEM from an early age so that at primary, secondary and tertiary levels students will be more confident to pursue STEM pathways.

1.2 Objectives

These objectives are structured to provide a comprehensive view of how the RBTx Robot Tracer Program influences students in the context of STEM, utilizing SCCT theory as the main conceptual framework. The study objectives targeted by the researchers in this study are to:

i. To analyze the effect of the RBTx Robot Tracer Program on students' Self-Efficacy in STEM.

ii. To evaluate the role of the RBTx Robot Tracer Program in shaping students' Outcome Expectations regarding STEM careers.

iii. To measure the influence of the program on students' Interest and Educational Goals in STEM.

2. LITERATURE REVIEW

Enhancing students' interest in STEM is a main focus in preparing the young generation for a knowledge-based economy. Research shows that students' interest in STEM is often hindered by internal and external motivational factors, including perceptions that these subjects are difficult and less relevant to daily life. Lack of exposure to real-world applications also contributes to declining interest. An emphasizes that a lack of external support, such as encouragement from family and community, also prevents students from choosing STEM pathways [11].

In this context, Social Cognitive Career Theory (SCCT) provides crucial guidance for understanding how self-efficacy and outcome expectations influence students' interest and career decisions in STEM [12]. Practical experiences and real-world applications play an important role in increasing students' self-efficacy [6]. Robotics programs offering practical exposure not only improve students' effective communication but also enhance their self-efficacy in STEM, consistent with SCCT which emphasizes active engagement in practical activities [13].

Hands-on and project-based approaches effectively attract students to STEM [14][5]. The further show that summer robotics camps increase STEM career interest and strengthen students' knowledge structures, underscoring the role of experiential learning in shaping career interest per SCCT [15].

Robotics programs have a significant positive impact on self-efficacy among primary school students regardless of gender [16]. This underscores the potential of programs like RBTx Robot Tracer to provide practical platforms that increase interest, self-efficacy and outcome expectations in STEM, and to open up future career opportunities.

3. RESEARCH METHODOLOGY

This study was descriptive in nature using a survey method to obtain quantitative data related to empowering STEM interest through the RBTx Robot Tracer Program: Inspiring Educational and Career Goals. The research instrument was a questionnaire.

3.1 Population and Sample

The population comprised 160 primary school students from three (3) schools in the Port Dickson district who participated in the Community Service Program: Sharing Knowledge and Expertise - RBTx Robot Tracer. Therefore, the sample involved 154 respondents who were given the opportunity to participate in the program.

3.2 Research Instrument

The questionnaire was adapted from [17] and [18] to measure students' STEM career interest based on Social Cognitive Career Theory. The questionnaire contained four sections corresponding to the study objectives.

3.2.1 Section A: Respondent Demographics

This section included five items to collect background information: school, grade, age, gender, and prior attendance in robotics programs other than Robot Tracer RBTx.

3.2.2 Section B: Self-Efficacy in Robotics and STEM

This section contained four items to assess how participation in the RBTx Robot Tracer Program affected students' confidence in mastering robotics skills and STEM concepts, using a five-point Likert scale: Strongly Disagree (SD), Disagree (D), Not Sure (NS), Agree (A), Strongly Agree (SA).

3.2.3 Section C: Outcome Expectations regarding STEM Careers

This section contained three items to understand how the program influenced students' perceptions of long-term benefits from involvement in STEM, including career prospects and practical application of skills learned, using the same five-point Likert scale.

3.2.4 Section D: Interest and Educational Goals in STEM

This section contained five items to examine the extent to which the RBTx Robot Tracer Program fostered students' interest in STEM and helped them set clearer educational and career goals, using the same five-point Likert scale.

4. RESULTS AND DISCUSSION

4.1 Respondent Demographics

Table 1 shows that most participants were Year 6 students among the three (3) selected schools. Male participation was higher than female, though the gender difference was not large. Most students had not attended robotics programs other than Robot Tracer RBTx, indicating the need for more STEM and robotics programs to expose students to the world of technology.

Table 1: Sample Demographics

Sample Distribution by Category		Frequency (F)	Percentage (%)
School	Sekolah Kebangsaan Intan Perdana	41	26.6
	Sekolah Kebangsaan Tanjong Agas	24	15.6
	Sekolah Kebangsaan Linggi	88	57.1
Grade	Grade 4	32	20.8
	Grade 5	60	39.0
	Grade 6	62	40.3
Age	10 years	32	20.8
	11 years	60	39.0
	12 years	62	40.3
Gender	Male	105	68.2
	Female	49	31.8
Attended other robotics aside from RBTx?	Yes	5	3.2
	No	149	96.8

4.2 Self-Efficacy in Robotics and STEM

Analysis in this section is based on four items in Section B of the questionnaire. Table 2 shows an overall mean of 4.47 for students' self-efficacy in robotics and STEM. Students reported the highest mean for being confident in understanding basic robotics concepts (mean = 4.61). They also expressed confidence in continuing STEM learning (mean = 4.49), in solving technical robotics problems after the program (mean = 4.45), and in applying knowledge from the program to other STEM projects (mean = 4.35).

Table 2: Self-Efficacy in Robotics and STEM (Item-level)

Statement	Percentage and Frequency					Mean
	SD **f** **%**	**D** **f** **%**	**NS** **f** **%**	**A** **f** **%**	**SA** **f** **%**	
1. I am confident in my ability to understand basic robotics concepts.	0 0	0 0	2 1.3	56 36.4	**96** **62.3**	**4.61**
2. I am able to solve technical problems related to robotics after participating in this program.	0 0	0 0	4 2.6	**76** **49.4**	74 48.1	**4.45**
3. I feel confident to continue studying in STEM after participating in this program.	0 0	0 0	5 3.2	65 42.2	**83** **53.9**	**4.49**
4. I feel confident using the knowledge learned from this program in other STEM projects.	0 0	0 0	12 7.8	**75** **48.7**	67 43.5	**4.35**

Overall Mean: 4.47

Note: The bold numbers represent the highest frequency achievement.

4.3 Outcome Expectations Regarding STEM Careers

This analysis is based on three items in Section C. Table 3 shows an overall mean of 4.49. Students agreed that skills learned in the program would help in future careers (mean = 4.55), that their Robot Tracer RBTx experience would benefit future STEM learning (mean = 4.43), and that robotics skills acquired would open better employment opportunities in technology (mean = 4.49).

Table 3: Outcome Expectations Regarding STEM Careers (Item-level)

Statement	Percentage and Frequency					Mean
	SD **f** **%**	**TS** **f** **%**	**SD** **f** **%**	**S** **f** **%**	**SD** **f** **%**	
5. I believe the skills learned in this program will help me in my future career.	0 0	0 0	7 4.5	55 35.7	**92** **59.7**	**4.55**
6. I expect that the experience with Robot Tracer RBTx will benefit my subsequent STEM learning.	0 0	0 0	2 1.3	**83** **53.9**	69 44.8	**4.43**
7. I am confident that the robotics skills gained through this program will open better job opportunities in technology.	0 0	0 0	6 3.9	66 42.9	**82** **53.2**	**4.49**

Overall Mean: 4.49

Note: The bold numbers represent the highest frequency achievement.

4.4 Interest and Educational Goals in STEM

This section is based on five items in Section D. Table 4 shows that the mean for interest and educational goals in STEM was high at 4.53. Students reported increased interest in learning more about robotics (mean = 4.57), intent to pursue further STEM studies (mean = 4.53), plans to enroll in additional robotics courses (mean = 4.55), and changes in career goals to include technology as a primary option (mean = 4.53). They also set goals to join other robotics programs or activities in the future (mean = 4.51).

This clearly shows that students are interested in learning more deeply about robotics. They are also interested in continuing their studies in the STEM field after gaining experience from participating in the RBTx Robot Tracer Program. Students also plan to take additional courses in robotics after joining this program. However, there are a few students who were uncertain or disagreed with these statements. Similarly, for the statement 'This program has changed my career goals to include technology as my primary choice,' some students were uncertain or disagreed. Nevertheless, the highest percentage indicates that most students are interested in making technology their primary career option.

Table 4: Interest and Educational Goals in STEM (Item-level)

Statement	Percentage and Frequency					Mean
	SD **f** **%**	**TS** **f** **%**	**SD** **f** **%**	**S** **f** **%**	**SD** **f** **%**	
8. After participating in this program, I am more interested in learning more about robotics.	0 0	0 0	5 3.2	55 35.7	**94** **61.0**	**4.57**
9. I am more interested in continuing my studies in STEM after the experience with Robot Tracer RBTx.	0 0	0 0	3 1.9	66 42.9	**85** **55.2**	**4.53**
10. I intend to take additional courses in robotics after participating in this program.	0 0	0 0	3 1.9	63 40.9	**88** **57.1**	**4.55**
11. This program has changed my career goals to include technology as a primary option.	0 0	0 0	3 1.9	65 42.2	**88** **55.8**	**4.53**
12. I have set a goal to participate in other robotics programs or activities in the future.	0 0	0 0	8 5.2	59 38.3	**87** **56.5**	**4.51**

Overall Mean: 4.53

Note: The bold numbers represent the highest frequency achievement.

4.5 Overall Findings

Referring to Table 5, overall analysis shows that the levels of self-efficacy in robotics and STEM, outcome expectations regarding STEM careers, and interest and educational goals in STEM were at a high level with an overall mean score of 4.49.

Table 5: Overall Analysis - Empowering STEM Interest through the RBTx Robot Tracer Program

ASPECT	MEAN
Self-Efficacy in Robotics and STEM	4.47
Outcome Expectations regarding STEM careers	4.49
Interest and Educational Goals in STEM	4.53
Overall Mean	**4.49**

5. CONCLUSION

The analysis found that empowering STEM interest through the RBTx Robot Tracer Program can inspire students' educational and career goals. This is evident from the data analysis of 154 respondents, which showed a high overall mean score of 4.49.

Overall, the measured levels indicate that students who participated in this program demonstrated increased confidence in robotics and STEM. It is important to provide physical contexts and comprehensive applications as well as more hands-on programs to further expand students' confidence in learning and exploring robotics technologies. Students also appear more inclined to solve technical problems related to robotics and STEM using higher-order thinking skills (HOTS).

Outcome expectations regarding STEM careers should be further promoted to young people from an early age. Students will be more motivated and competitive to make robotics and STEM their future careers. Integration of the four disciplines — science, technology, engineering and mathematics — should be emphasized and explored by organizing field programs to expose students to the importance of these subjects in daily life and future careers.

Interest and educational goals in STEM ought to be nurtured so that students perceive robotics and STEM as enjoyable pathways to acquire knowledge in the industry 4.0 era. Schools and institutions should take initiative by organizing programs such as Robot Tracer RBTx and robotics competitions at school, institutional or agency levels to demonstrate that robotics and STEM can produce highly educated and skilled students in line with the Ministry of Education’s aspirations.

According to Nor, L (2019), STEM education needs to evolve, adapt, and be revitalized in line with the changing needs of the current education system. STEM education is based on the philosophy of educating students by integrating and applying the four (4) main fields of science, technology, engineering, and mathematics in real-world contexts. Facts have shown that the presence of STEM learning can attract students' interest, challenge their thinking and creativity through engaging lessons and activities, and provide a deeper impact on students.

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