Cultivating Students' Interest in STEM through Hands-on Activities: A Case Study of the Tiny Techies Initiative

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ABSTRACT

The declining interest in science, technology, engineering, and mathematics (STEM) among Malaysian students remains a pressing concern for the nation's future workforce. This study investigates the effectiveness of the Tiny Techies initiative, a STEM outreach programme designed to nurture students' interest and aspirations through hands-on learning. The programme was conducted at Universiti Teknologi MARA (UiTM) Melaka, Alor Gajah, in August 2025, involving 65 students from primary and secondary schools across six states in the central and southern zones. Over two days, students were introduced to STEM and robotics concepts before collaborating in groups to design and compete with their own robots. A survey instrument using a five-point Likert scale was administered to assess their understanding of STEM, enjoyment of activities, technological confidence, and future aspirations. The results revealed positive responses, with the majority of students expressing enjoyment, willingness to join similar programmes, and interest in pursuing STEM studies. Cross-tabulation further indicated that primary school students demonstrated greater enthusiasm for activities, while secondary school students were more inclined towards long-term aspirations in STEM. However, confidence in technical skills and innovation under time constraints remained moderate. These findings suggest that short-term programmes can effectively spark curiosity and aspiration, but sustained initiatives are required to strengthen competence and long-term commitment. The study highlights the importance of experiential, robotics-based learning in promoting STEM engagement and provides useful insights for educators and policymakers.

Keywords: STEM Education, Tiny Techies, Robotics-Based Learning

INTRODUCTION

STEM (Science, Technology, Engineering, and Mathematics) education is universally recognised as essential for equipping future generations to meet the demands of a progressively technology-oriented labour market. The Malaysia Education Blueprint 2013–2025 emphasises the importance of strengthening STEM to ensure a sustainable talent pipeline capable of driving innovation, competitiveness, and economic growth (Ministry of Education Malaysia, 2013). Nevertheless, despite continuous national initiatives, Malaysia continues to face challenges in cultivating student interest in STEM education.

Recent statistics highlight a persistent gap between national goals and actual outcomes. Despite the government's long-standing target of achieving 60% enrolment in STEM fields, participation in 2024 stood at 50.8% (Nur Sofea Hasmira Azahar, 2024). Fig. 1 illustrates the trend of STEM education enrolment in Malaysia from 2016 to 2024. The 2024 enrolment rate of 50.83% reflects gradual progress towards the 60% target; however, sustaining this growth requires continuous innovation and collaborative support beyond government efforts alone. The Ministry of Education has reported that students perceive STEM subjects as challenging, unattractive, and less relevant to daily life. This issue is further exacerbated by limited exposure to practical applications, a shortage of educators skilled in innovative teaching methods, and unequal access to modern educational facilities, particularly in rural areas. (Idris et al., 2023, 2024; Liew & Teoh, 2022; Riduan & Othman, 2024; Siew, 2017). To address these challenges, several initiatives have been introduced, including Tiny Techies, a national programme designed to stimulate early interest in STEM through robotics and technology-based learning (Tiny Techies, 2025).

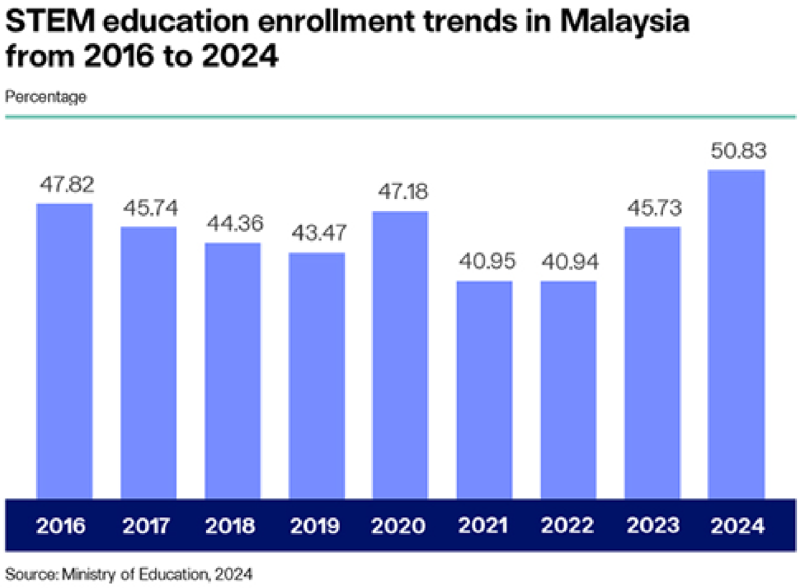

Fig. 1. STEM Education Enrolment Trend in Malaysia (2016 - 2024)

The effects of declining STEM participation are reflected in global performance indices. Malaysia's results in the Programme for International Student Assessment (PISA) 2022 indicated significant declines in mathematics (–32 points), reading (–27 points), and science (–21 points) compared to 2018, representing a decrease equivalent to one to two years of academic achievement (Organisation for Economic Co-operation and Development, 2023). Although the 2024 Sijil Pelajaran Malaysia (SPM) results showed the highest overall national performance since 2013—with the National Average Grade improving to 4.49 from 4.60 (Examinations Syndicate, Ministry of Education Malaysia, 2024)—the persistent challenge of sustaining student interest in STEM remains unresolved.

Addressing these challenges requires more than incremental reforms. Effective strategies should prioritise improving teaching quality, implementing engaging pedagogical approaches, enhancing guidance, and fostering partnerships between academia and industry. One notable initiative is Tiny Techies, which has been implemented across four regions in Malaysia to ensure equitable access to practical STEM learning experiences.

Universiti Teknologi MARA (UiTM) Cawangan Melaka organised the Central and Southern Zone edition in August 2025, strengthening university–community collaborations to promote STEM education. Initial evaluations yielded encouraging outcomes, with participants demonstrating heightened engagement, improved problem-solving abilities, and a growing interest in STEM-related disciplines and careers. By integrating STEM education with practical applications and measurable student outcomes, initiatives such as Tiny Techies advance Malaysia's efforts to sustain interest in STEM and develop a highly skilled workforce aligned with the nation's aspiration to transition towards a knowledge and innovation-driven economy.

Therefore, the objectives of this study are:

- To examine the effectiveness of the Tiny Techies programme in enhancing students' understanding, interest, and aspiration in STEM.

- To assess whether experiential learning through robotics can improve students' motivation towards STEM fields.

LITERATURE REVIEW

STEM education has been widely recognised as one of the most crucial elements in equipping students with the skills required to thrive in innovation-driven nations. Nevertheless, Malaysia continues to face challenges in attracting and retaining students in STEM-related fields. Studies have found that participation remains low despite the government's target of 60% STEM enrolment, as many students perceive mathematics and science as excessively difficult, abstract, or irrelevant to daily life (Nadzreeq, 2025). This concern is reflected in the 2022 PISA results, which revealed a significant decline in mathematics, science, and reading performance—an indication of declining student confidence (Ikram, 2023). Researchers have acknowledged that the nation's examination-oriented teaching culture and limited opportunities for practical applications may exacerbate disengagement, particularly among students in rural areas (Yu & Luen, 2025).

One promising strategy to address these issues is the adoption of experiential and activity-based learning approaches. These include hands-on activities such as robotics, coding, and STEM competitions, which have been shown to enhance intrinsic motivation, curiosity, collaboration, and problem-solving as well as creativity (Nadzreeq, 2025; Syed Tanzim Mubarrat, 2024). Initiatives such as UTM's iSTeM21 and Robotics Revolution have demonstrated students' capability to design and build tangible artefacts when they view STEM as relevant and attainable (Mastura Shafinaz, 2024; Nurul Ashikin A. K., 2024). One of the most recent STEM initiatives at UTM, Robotics for All, expanded access to schools with limited capital, funding, or infrastructure—showing that immersive involvement can foster passion across diverse student backgrounds (Ibnuzaman, 2025).

At the policy level, the Malaysian government has invested considerable interest and resources in STEM programmes, including competitions and infrastructure upgrades, as highlighted in the 2024 national budget (Bernama, 2023). However, many initiatives remain short-sighted in achieving long-term goals, raising concerns about the sustainability and enduring impact of the nation's STEM agenda. Without consistent reinforcement, the enthusiasm generated during such programmes risks fading over time. This highlights the need for a sustainable structure and continuous engagement from both organisers and schools (Markom et al., 2024).

This approach aligns with Experiential Learning Theory (ELT), which posits that knowledge is best constructed through a cyclical process of experience, reflection, and experimentation (Kolb, 1984). Recent studies have shown that robotics-based and project-based STEM programmes enhance both technical skills and affective engagement, particularly when integrated within iterative learning cycles (Ouyang & Xu, 2024). Past case studies in Malaysia have reported similar findings, indicating that robotics engagement boosts students' self-confidence and their sense of relevance and ownership when learning outcomes are manifested through prototypes and peer demonstrations (Aspin et al., 2022). Nonetheless, researchers have cautioned that short-term exposure to STEM programmes alone is insufficient; sustained experiential opportunities are vital to transform initial curiosity into long-term interest, competence, and knowledge (Parappilly et al., 2025).

This gap highlights the importance of studies such as the present one, which aims to investigate how structured robotics-based programmes like Tiny Techies can cultivate consistent engagement with STEM among Malaysian students.

METHODOLOGY

Research Design

This study employed a quantitative research design using a questionnaire survey. According to Creswell (2012) and Cohen et al. (2018), researchers who aim to compare groups, make objective measurements, and produce numerical data suitable for statistical analysis should adopt a quantitative approach. The descriptive and comparative analyses in this study aim to evaluate differences in comprehension and perception between primary and secondary school students.

Participants

A total of 65 primary and secondary school students from Johor, Melaka, Negeri Sembilan, Kuala Lumpur, Putrajaya, and Selangor participated in this study. As descriptive quantitative studies typically require a sample size larger than 30 to ensure data reliability, this number was deemed sufficient (Creswell, 2012). For small populations, a sample of 60–70 respondents is adequate to achieve a 95% confidence level, according to the Krejcie & Morgan (1970) table. Consequently, the 65 participants in this study met the required standards and were appropriate for comparing primary and secondary education levels.

Program Structure

The two-day session incorporated activities based on an active learning approach. The first day covered an introduction to STEM and basic robotics, while the second day focused on team-building activities, including robot construction and competition. Such collaborative and hands-on approaches are recommended in STEM education as they enhance students' attention, comprehension, and engagement (Hmelo-Silver, 2004; Prince, 2004).

Instrument

The research instrument comprised a questionnaire with 12 items designed to measure students' understanding, interest, skills, and aspirations regarding STEM. Each item was rated using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The use of a Likert scale is appropriate, as it is commonly employed in educational research to assess respondents' attitudes and perceptions.

Data Collection

A post-programme survey was administered to participants upon completion of the activities. The purpose of this post-programme data collection was to assess students' experiences and perceptions after their participation. Post-programme surveys, such as the one used in this study, are widely implemented in educational research to capture immediate feedback on the impact of learning programmes (Cohen et al., 2018).

Data Analysis

Descriptive statistics (percentage and mean) and cross-tabulation were employed to analyse the data and compare responses between primary and secondary students. Descriptive statistics are essential for summarising data patterns, whereas cross-tabulation is suitable for identifying group differences (Pallant, 2020).

A cross-sectional comparison between primary and secondary school students was used because interests and attitudes may vary according to age and learning stage. Previous literature has shown that interest in STEM tends to decline during the transition to secondary school due to factors such as self-efficacy, curriculum design, and gender differences (Maltese & Tai, 2011; Sadler et al., 2012).

Therefore, this comparison is significant in determining whether such programmes can sustain or enhance students' interest as they progress through different educational phases. The findings are expected to assist schools and policymakers in designing targeted interventions to address specific developmental needs.

FINDINGS AND DISCUSSION

The survey results, as presented in Table 1, indicate that the Tiny Techies initiative had a positive impact on participating students' perceptions of STEM.

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Table 1. Students' Responses to STEM Perception and Interest

No.	Question	Strongly Disagree [1]	Disagree [2]	Neutral [3]	Agree [4]	Strongly Agree [5]
1	I understand the concept of STEM.	2%	3%	12%	54%	29%
2	I know about STEM fields.	0%	5%	15%	48%	32%
3	I am interested in learning STEM subjects.	2%	5%	6%	46%	42%
4	I enjoy STEM activities.	0%	5%	2%	26%	68%
5	I want to participate in STEM programs.	0%	5%	12%	29%	54%
6	I am attracted to carrying out STEM activities.	0%	3%	9%	45%	43%
7	I am skilled at using technological tools.	0%	6%	26%	28%	40%
8	I can produce a technological product within the given period of time.	0%	2%	40%	28%	31%
9	I want to continue my studies in the STEM field.	2%	3%	17%	31%	48%
10	I have career ambitions related to STEM.	0%	3%	23%	32%	42%
11	Activities like this increase my interest in STEM.	0%	3%	11%	40%	46%
12	Understanding STEM should be developed through outdoor or extra-curricular activities like this.	2%	2%	11%	34%	52%

A large majority of students (83%) either agreed or strongly agreed that they understood the concept of STEM after completing the programme, suggesting that the introductory workshops successfully enhanced conceptual clarity. Similarly, 80% of participants reported familiarity with STEM-related fields, reflecting the programme's effectiveness in raising awareness. Enjoyment emerged as a particularly strong outcome, with 94% of students agreeing or strongly agreeing that they enjoyed the activities, and 68% selecting the highest scale point. This indicates that the hands-on, robotics-based approach created an engaging and stimulating learning environment.

In terms of interest, 88% of students expressed a willingness to join similar programmes in the future, while 84% indicated that they were attracted to STEM-related activities. More importantly, aspirations were positively influenced by the programme. Nearly half of the participants (48%) strongly agreed that they would like to pursue further studies in STEM, and 42% expressed career ambitions in related fields. These results suggest that short-term exposure, when structured around active learning, can influence students' long-term academic and career orientations.

However, confidence in technological skills was less pronounced. While 68% of students agreed or strongly agreed that they could use technological tools effectively, only 31% strongly agreed that they could produce a functioning technological creation within the time provided. This reveals a gap between enthusiasm and skill mastery—indicating that while students were highly motivated and engaged, their confidence in applying technical competencies remained moderate, reflecting the brief duration of the programme.

Cross-tabulation analysis revealed notable differences between primary and secondary school participants. As shown in Table 2, primary students demonstrated greater enthusiasm for the activities, with 66% strongly agreeing that they enjoyed the programme. For this group, enjoyment and novelty appeared to be the primary motivational drivers. In contrast, secondary students displayed stronger aspirations for STEM education and careers, with 53% strongly agreeing that they envisioned pursuing STEM pathways. Although their enjoyment levels remained high, they placed greater emphasis on STEM's potential to shape their future academic and professional trajectories. Both groups, however, shared moderate confidence in producing technological outputs within the allocated time, reflecting a common challenge across age levels.

Table 2. Comparison of Primary and Secondary School Students' Responses to STEM Perception and Interest (Likert Scale from 1=Strongly Disagree; to 5=Strongly Agree).

No.	Question	Primary School (n=35)					Secondary School (n=30)				
		1	2	3	4	5	1	2	3	4	5
1	I understand the concept of STEM.	0%	6%	20%	49%	26%	3%	0%	3%	60%	33%
2	I know about STEM fields.	0%	3%	20%	49%	29%	0%	7%	10%	47%	37%
3	I am interested in learning STEM subjects.	0%	9%	9%	49%	34%	3%	0%	3%	43%	50%
4	I enjoy STEM activities.	0%	3%	3%	29%	66%	0%	7%	0%	23%	70%
5	I want to participate in STEM programs.	0%	6%	14%	23%	57%	0%	3%	10%	37%	50%
6	I am attracted to carrying out STEM activities.	0%	3%	9%	40%	49%	0%	3%	10%	50%	37%
7	I am skilled at using technological tools.	0%	6%	17%	37%	40%	0%	7%	37%	17%	40%

8	I can produce a technological product within the given period of time.	0%	0%	40%	31%	29%	0%	3%	40%	23%	33%
9	I want to continue my studies in the STEM field.	0%	3%	17%	37%	43%	3%	3%	17%	23%	53%
10	I have career ambitions related to STEM.	0%	0%	29%	40%	31%	0%	7%	17%	23%	53%
11	Activities like this increase my interest in STEM.	0%	0%	17%	20%	34%	0%	7%	3%	30%	60%
12	Understanding STEM should be developed through outdoor or extra-curricular activities like this.	0%	0%	14%	46%	40%	3%	3%	7%	20%	67%

These findings highlight the effectiveness of short-term experiential learning in fostering interest and cultivating positive attitudes towards STEM. The high levels of enjoyment and willingness to participate in future programmes highlight the motivational potential of experiential, robotics-based activities. This aligns with Kolb's (1984) Experiential Learning Theory, which posits that active, hands-on engagement enables students to internalise concepts more effectively than through passive instruction. The students' responses demonstrate that when STEM is taught through real-world problem-solving and collaborative projects, it becomes more accessible and appealing.

A Chi-square test of independence examined whether prior participation in any STEM programme differed significantly between primary ($n = 35$) and secondary ($n = 30$) students. The distribution did not differ significantly between the two groups, $\chi2$ $(1, N = 65) = 0.511$, $p = 0.475$. Given the small subgroup sample sizes, Fisher's Exact Test was also evaluated, yielding no statistically significant difference ($p = .526$, two-tailed). The effect size was negligible ($\phi= 0.089$), indicating that student education level was not meaningfully associated with response distribution on this measure.

To assess the internal consistency of the post-programme survey instrument, Cronbach's alpha was computed across the 12 items using the combined sample ($N = 65$). The overall scale demonstrated excellent reliability ($\alpha= 0.912$), standardized ($\alpha = 0.913$), indicating that the items reliably measured students' post-activity STEM interest and engagement.

Overall, students reported high levels of post-programme interest and engagement, with a substantial proportion expressing interest in pursuing further studies and careers in STEM. This finding aligns with Nugent et al. (2019), who reported that robotics competitions significantly enhance students' STEM-related ambitions. Nevertheless, the moderate levels of technical confidence suggest that a two-day programme, while effective in generating enthusiasm, is insufficient for developing sustained competence. This observation supports Li et al. (2021), who argued that short-term interventions should be complemented by long-term, structured learning opportunities to reinforce skill development.

The distinction between primary and secondary school participants provides further insight into the developmental dimensions of STEM engagement. Primary students, driven primarily by enjoyment and novelty, represent the early-stage motivational potential of such initiatives. In contrast, secondary students approach STEM with a stronger sense of purpose, linking the activities to their future aspirations. This progression mirrors educational development theories, in which younger learners are more play-oriented, whereas older students begin aligning learning with identity formation and long-term goals (Eccles & Wigfield, 2002).

Overall, the findings suggest that experiential STEM learning offers dual benefits: it sparks curiosity among younger learners and reinforces career-oriented aspirations among older students. However, without ongoing reinforcement, these motivational gains risk diminishing over time. Policymakers and educators should therefore view programmes such as Tiny Techies as entry points rather than stand-alone solutions. Sustained engagement, mentorship, and integration of robotics-based STEM modules into school curricula are essential to bridging the gap between short-term enthusiasm and long-term competence.

CONCLUSION AND RECOMMENDATIONS

The findings of this study affirm the effectiveness of the Tiny Techies initiative in fostering students' awareness, motivation, and aspirations in STEM through experiential, hands-on learning. The programme generated high levels of interest and enjoyment among participants, particularly through its robotics-based activities. Primary school students exhibited greater enthusiasm and engagement, while secondary students demonstrated more pronounced aspirations towards pursuing future STEM studies and careers—reflecting developmental differences in motivational factors. These outcomes highlight the programme's relevance across different school levels.

Despite its short duration, the programme effectively boosted motivation, suggesting that well-designed, activity-based outreach initiatives can influence students' academic interests and long-term goals in STEM education. These results also reinforce the theoretical premise of experiential learning, which posits that knowledge acquisition is enhanced through active participation and contextual application.

To support the continued effectiveness of the program, several practical recommendations are proposed. First, the initiative should be expanded to reach a broader range of schools, particularly in underserved rural areas where STEM exposure remains limited. Second, follow-up programs involving more advanced content are needed to strengthen students' technical confidence beyond the introductory level.

Third, integrating robotics and project-based STEM modules into the formal school curriculum can ensure continuity. Finally, longitudinal research should be conducted to assess the lasting effects of such programs on students' academic pathways and enrolment in STEM disciplines. Collectively, these measures can support the development of a more inclusive and sustainable STEM talent pipeline, aligning with Malaysia's educational and workforce development objectives.

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