Enhancing STEM Interest through Robotics Education in a Malaysian Primary School

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Abstract

This study investigates the impact of robotics education on enhancing STEM interest among students in a Malaysian primary school. As Malaysia aims to become a technological innovation hub, fostering STEM interest in youth is crucial. Traditional education methods focusing on rote memorization contribute to a significant gap in practical STEM skills, especially in robotics. This study addresses these challenges through a mixed-methods approach, conducting a "Robotic Day" workshop at SJK(C) Pei Chih for 30 Standard 5 students. Pre- and post-workshop surveys and in-depth interviews assessed changes in students' STEM knowledge, attitudes, and interests. Results showed a significant increase in students' understanding and enthusiasm for STEM, with the proportion of participants demonstrating good and very good levels of knowledge rising from 10.3% to 69.2%. Additionally, the percentage of students with low interest in STEM dropped from 44.8% to 7.6% post-workshop. These findings underscore the effectiveness of hands-on robotics education in bridging educational gaps, fostering critical thinking, and nurturing future STEM professionals. This study supports Sustainable Development Goal 4, promoting inclusive and equitable quality education.

Keywords

Robotics Education, STEM, Student Engagement, Teaching and Learning

Introduction

In the contemporary era of rapid technological advancement, fostering an interest in science and technology among the youth is paramount for national development and global competitiveness, especially as Malaysia strives to position itself as a leading hub for technological innovation (Malaysia Education Blueprint 2015-2025, Ministry of Education Malaysia). Embracing digital technology is essential for staying competitive, driving innovation, and navigating the

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complexities of the modern era, highlighting the critical need to nurture a skilled workforce equipped with science, technology, engineering, and mathematics (STEM) competencies.

However, despite efforts to promote STEM education initiatives, there persists a notable gap in equipping students with the requisite knowledge, skills, and interest in these disciplines. One significant challenge lies in the traditional approach to education, which often emphasizes rote memorization over practical, hands-on learning experiences. This deficiency is particularly pronounced in the realm of robotics education, where the lack of access to resources, inadequate teacher training, and limited integration of robotics into the curriculum hinder students' ability to develop essential STEM competencies. Additionally, socio-economic disparities exacerbate these challenges, as students from marginalized communities often face barriers to accessing quality STEM education opportunities. As a result, there is a pressing need to address these systemic issues and explore innovative strategies for enhancing robotics education in Malaysian schools. By bridging the gap between theory and practice, fostering collaboration among stakeholders, and promoting inclusivity in STEM education, this study seeks to contribute to the development of a more robust and equitable educational ecosystem that empowers all students to succeed in the digital age.

Robotics education emerges as a promising avenue to engage students in practical, experiential learning experiences that not only enhance technical proficiency but also cultivate critical thinking, problem-solving skills, and creativity (Huang & Meinel, 2019). By integrating robotics into the educational curriculum, Malaysia seeks to address the growing demand for STEM professionals and empower its youth to become active contributors to the digital economy (World Economic Forum, 2020). This comprehensive initiative aims to explore the implementation of hands-on robotics programs in Malaysian schools, emphasizing the role of practical learning experiences in fostering interest and proficiency in science and technology among the next generation.

In the realm of robotics education, an increasing body of literature underscores its transformative potential in engaging students and fostering interest in STEM fields. Research by Jones and Oakes (2018) emphasizes the effectiveness of hands-on learning approaches, highlighting their ability to deepen students' understanding of robotics concepts and enhance retention. Similarly, studies by Smith et al. (2020) have shown that hands-on activities in robotics education promote active engagement and practical skill development, ultimately leading to greater enthusiasm for STEM subjects. Furthermore, Huang and Meinel (2019) underscore the role of robotics education in inspiring students to pursue careers in STEM fields, citing its positive impact on career aspirations and academic achievement.

Despite the promising outcomes associated with robotics education, challenges exist in its implementation within educational settings. Ghani et al. (2017) identify barriers such as limited access to resources, inadequate teacher training, and curriculum constraints, which hinder the effective integration of robotics into the classroom. Ren et al. (2020) further highlight the need for comprehensive strategies to address these challenges and maximize the impact of robotics education initiatives. Additionally, Khan et al. (2021) emphasize the importance of addressing equity issues to ensure that all students, regardless of socioeconomic background, have equal access to robotics education opportunities.

To address these challenges and maximize the benefits of robotics education, researchers have proposed various strategies and best practices. One approach involves curriculum integration, where robotics activities are aligned with existing STEM subjects to reinforce learning outcomes and promote interdisciplinary connections (Ghani et al., 2017). Another strategy focuses on teacher

professional development, providing educators with the necessary training and support to effectively incorporate robotics into their teaching practices (Ren et al., 2020). Additionally, community partnerships and outreach programs can enhance access to robotics education for underserved populations, thereby promoting equity and inclusivity in STEM learning (Khan et al., 2021). By implementing these strategies, educational institutions can harness the full potential of robotics education to inspire and empower the next generation of STEM innovators.

In Malaysia, robotics education has gained traction as a means to bolster STEM (Science, Technology, Engineering, and Mathematics) competencies among students and enhance the nation's technological capabilities. Research within the Malaysian context has explored the effectiveness of robotics education in engaging students and fostering interest in STEM fields. Studies by Lim et al. (2019) and Ahmad et al. (2020) have highlighted the positive impact of robotics competitions and workshops on students' motivation and academic performance in STEM subjects. These initiatives not only provide hands-on learning experiences but also cultivate critical thinking, problem-solving skills, and teamwork among participants.

Methodology

This study employs a quantitative method to assess the impact of robotics education through a "Robotic Day" workshop on students' interest in STEM fields in Malaysia. Conducted at SJK(C) Pei Chih on 14 August 2023 for 30 Standard 5 students (11 years old) as part of the 'Empowerment Program in Digital Knowledge & Robotic Technology,' the research involved both quantitative and qualitative phases. Pre- and post-workshop surveys were electronically distributed to evaluate changes in participants' attitudes, perceptions, and knowledge related to STEM and robotics. The quantitative data from the surveys revealed significant changes in students' engagement and understanding of robotics education, providing a deeper understanding of the workshop's impact.

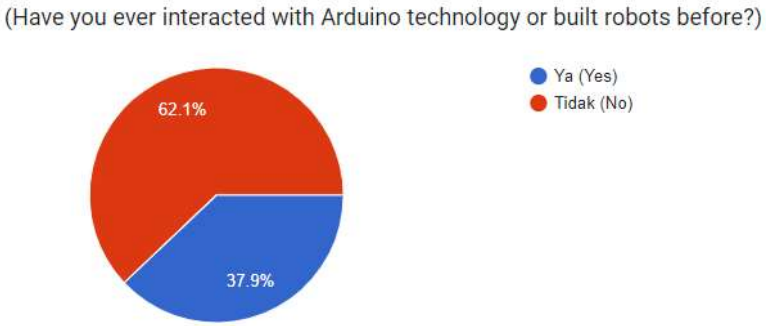

Figure 1. Student Exposure to Arduino Technology and Robotics Prior to the Workshop

Figure 1 is a survey before the workshop has been started. The survey results indicate that 62.1% of the students had never interacted with Arduino technology or built robots before, highlighting a significant lack of exposure to these crucial STEM skills. Introducing Arduino and robotics in schools is essential as they foster hands-on learning, critical thinking, and problem-solving abilities, preparing students for future technological advancements and careers in STEM fields.

Results and Discussion

The findings as shown in figure 2 (a) before and (b) after the robotic workshop regarding the level of knowledge about science, technology, and robotics among participants provide valuable insights into the effectiveness of the program in enhancing participants' understanding of STEM concepts. Before the program, a significant proportion of participants (62%) reported low and very low levels of knowledge in these areas, with only 27.6% indicating a medium level of knowledge and 10.3% reporting a good level. This initial distribution highlights the existing gaps in STEM education and the need for interventions to encourage participants' knowledge in these fields.

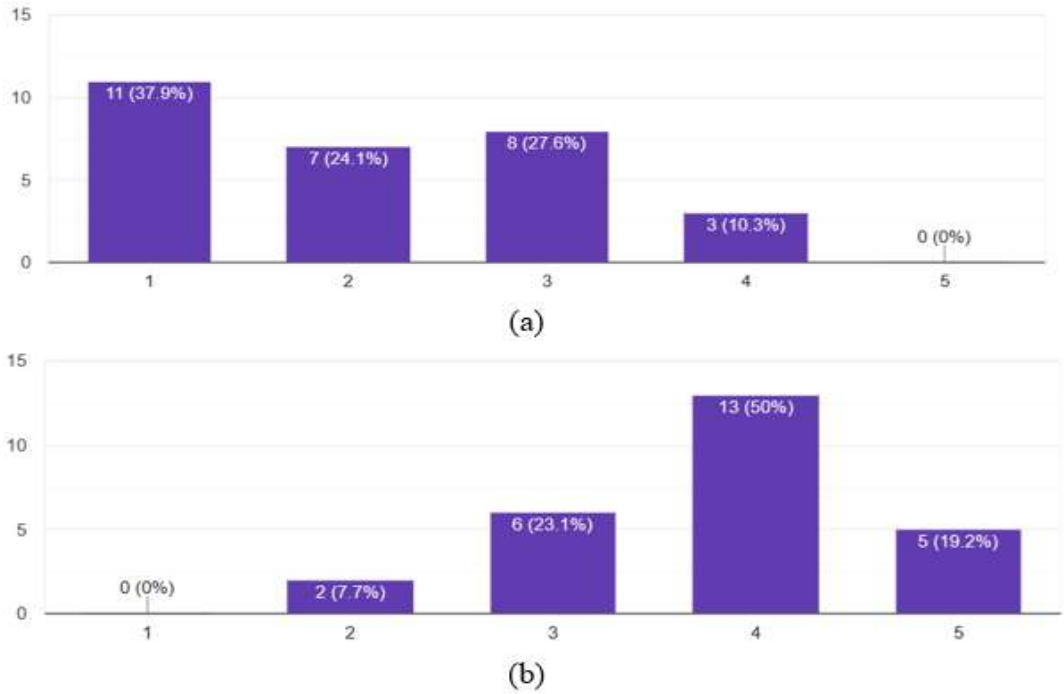

Figure 2. Level of knowledge about science, technology, and robotics (a) before (b) after the robotic program

Following the program, a notable shift in participants' knowledge levels was observed, indicating a positive impact on their understanding of science, technology, and robotics. Specifically, the proportion of participants with a good and very good level of knowledge increased substantially to 69.2%, reflecting a significant improvement compared to the pre-program assessment. Furthermore, the percentage of participants with a medium level of knowledge remained relatively stable at 23%, suggesting that the program effectively catered to participants with varying levels of prior knowledge.

The decrease in the proportion of participants with low levels of knowledge from 62% before the program to 7.5% after is particularly noteworthy, indicating a successful reduction in knowledge gaps among participants. This shift towards higher knowledge levels can be attributed to the comprehensive and engaging nature of the program, which likely provided participants with opportunities for hands-on learning, interactive experiences, and exposure to relevant STEM concepts. The assessment of participants' level of interest in the science, technology, and robotics field provides valuable insights into the program's effectiveness in stimulating enthusiasm and engagement among participants as shown in figure 3. Prior to the program, a considerable portion of participants (44.8%) reported low to very low levels of interest in these domains, with 24.1% indicating a very low level of interest, and an additional 20.7% reporting a low level. This initial

distribution underscores the importance of interventions aimed at igniting interest and curiosity in STEM subjects among participants who may initially lack enthusiasm in these areas.

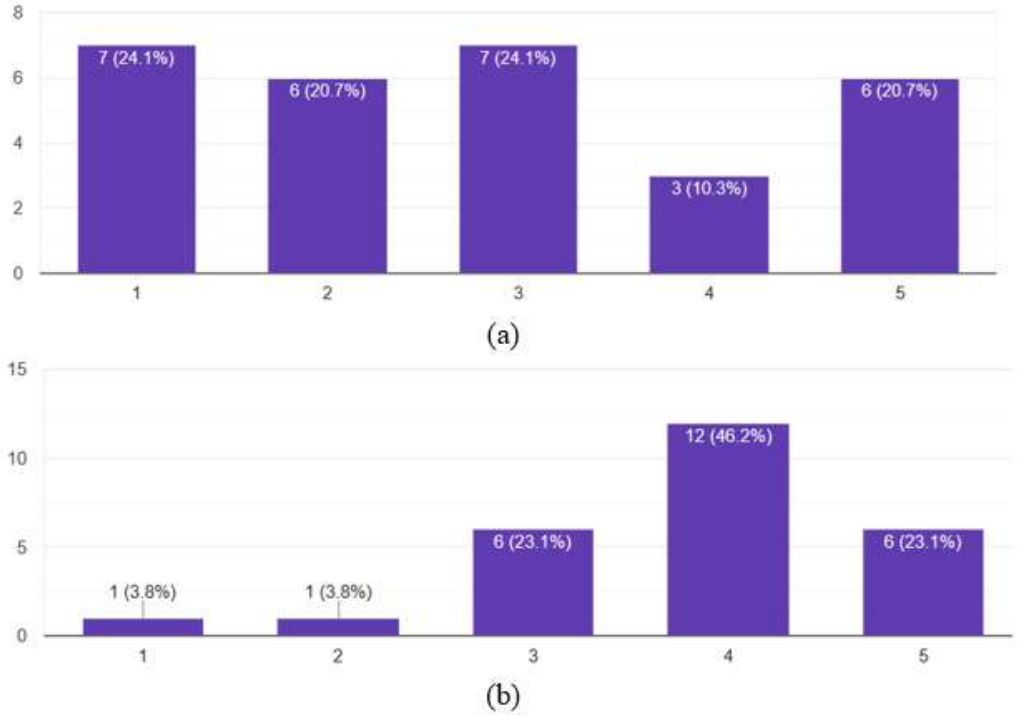

Figure 3. Level of interest in the science, technology, and robotics field (a) before (b) after the robotic program

Following the program, a significant shift in participants' interest levels was observed, reflecting a positive impact on their engagement with science, technology, and robotics. Notably, the proportion of participants with a good and very high level of interest increased substantially to 69.3%, representing a marked improvement compared to the pre-program assessment. This shift towards higher interest levels suggests that the program effectively succeeded in capturing participants' attention and fostering a greater appreciation for STEM fields. The decrease in the proportion of participants with low to very low levels of interest from 44.8% before the program to 7.6% after is particularly noteworthy, indicating a successful transformation in participants' attitudes towards science, technology, and robotics. This change can be attributed to the program's engaging and interactive components, which likely sparked curiosity, encouraged exploration, and inspired a deeper appreciation for STEM subjects among participants.

All students responded positively when asked about their interest in robotics and their desire to improve their skills in science and technology. This shows that participants are highly enthusiastic and committed. The complete consensus among all students on their affinity for robots demonstrates a widespread excitement and admiration for robotics, highlighting a solid basis of interest and curiosity in technological advancement. Moreover, the unanimous consensus to the intention of persistently acquiring knowledge and enhancing proficiency in science and technology emphasizes a shared resolve among participants to delve deeper into and actively participate in STEM disciplines, showcasing their inherent drive and preparedness to pursue understanding and mastery in these areas. The unanimous comments confirm that the program is successful in

developing a strong and lasting interest in robotics and inspiring participants to continue learning and improving their skills in the ever-changing fields of science and technology.

In conclusion, the robotics education program has successfully equipped participants with a multifaceted array of knowledge, skills, and soft skills essential for navigating the digital age. Participants have gained a comprehensive understanding of digital technology concepts and principles, alongside familiarity with diverse components and mechanisms employed in robotics. Moreover, they have acquired proficiency in programming languages and algorithms pertinent to robotics, empowering them to engage meaningfully in technological innovation. Additionally, participants have honed practical skills, demonstrating competence in constructing and programming robots to accomplish specific tasks, while also developing the ability to troubleshoot technical issues and debug robot functionalities.

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