Addressing Challenges in Design and Technology (Rekabentuk Teknologi-RBT) Subject: A Case Study on Enhancing Knowledge and Technical Skills

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Received: 23 November 2024; Accepted: 24 December 2024

Abstract
This research investigated the underlying issues of delivering Design and Technology (Rekabentuk Teknologi, RBT) subject in Malaysia education system and the effect of the empowerment of knowledge and technical. Some of the challenges are lack of resources, limited teacher training, lack of student interests and examination-oriented culture. School of Electrical and Electronics Engineering, Universiti Sains Malaysia (USM), have taken a proactive role in enhancing the knowledge and technical skills of secondary school students in RBT subject. In line with this, a comprehensive outreach program was successfully carried out, featuring training sessions and hands-on workshops. The workshop involved 64 students of secondary school from Form 2 and Form 3 students. The students' feedback was highly positive, with many expressing increased interest in Electricity, Electronics, and Arduino programming. The hands-on experience enhanced their understanding of RBT subjects and sparked a deeper interest in STEM fields. The group project phase was particularly well-received, fostering teamwork, problem-solving, and creativity. Overall, the workshop effectively bridged theory and practical application, leaving a lasting impact on students' skills and enthusiasm for further exploration in technology and engineering.

Keywords: STEM Education, Design and Technology Subject (RBT), Engineering Education.

Introduction

Science, Technology, Engineering, and Mathematics (STEM) are critical drivers of national progress and innovation. However, Malaysia continues to struggle with engaging more young people in STEM fields. In 2024, approximately 51% of students were enrolled in STEM streams, marking a decade-high percentage but still falling short of the government's 60:40 target, which aims for 60% of students to major in STEM disciplines (Ministry of Education, 2024). The Ministry of Education (MOE) has introduced the Malaysia Education Blueprint, a comprehensive plan with three implementation phases, spanning from 2013 to 2025. Among its targeted initiatives is the enhancement of Science, Technology, Engineering, and Mathematics (STEM) education across schools nationwide. This effort aligns with the country's goal of addressing future workforce demands, especially in response to the evolving needs brought about by the Fourth Industrial Revolution (Ministry of Education, 2013).

To support this vision, the Secondary Integrated Curriculum (KBSM) was progressively replaced by the Secondary Standard Curriculum (KSSM), which adopts a more integrated STEM approach. The KSSM framework, outlined in the Malaysia Education Blueprint (2013–2025), emphasizes the seamless integration of science, technology, engineering, and mathematics into educational practices nationwide (Yusof et al., 2021). This shift reflects a strategic move to prepare students for emerging challenges and opportunities in a technology-driven global landscape. To tackle the challenges in STEM education, a comprehensive restructuring of the curriculum is essential. The emphasis should move from covering an extensive range of topics to fostering critical thinking, enhancing problem-solving abilities, and integrating more hands-on, project-based learning experiences. Streamlining the curriculum does not equate to lowering standards but aims to create a more effective learning environment that helps students build a solid foundation while nurturing a genuine interest in STEM subjects (Wai Onn, H., 2024).

There has been lots of effort and support from various parties such as schools, university, non-government organizations and industrial companies performed to overcome this issue. Prime Minister of Malaysia, Datuk Seri Anwar Ibrahim's recent initiative, which involves 100 young scientists visiting schools nationwide to inspire interest in STEM, is a commendable step forward. Expanding on this concept, Malaysia could develop a broader STEM Ambassadors Program. This initiative would enlist professionals from diverse STEM backgrounds to engage actively with students, teachers, and communities. Through activities like school visits, interactive workshops, and career expos, these ambassadors could demonstrate real-world applications of STEM, offering students relatable role models and practical insights into potential career pathways.

Design and Technology (Reka Bentuk dan Teknologi) or known as RBT, is a new subject introduced as part of the Secondary School Standard Curriculum (KSSM) in 2017. The content of this new subject focuses on the daily application of technology, specifically through the implementation of RBT project work. Students' achievement and performance in RBT can be assessed through the quality of their project work. In this regard, the level of students' mastery can be assessed through their knowledge, skills, values, and creativity (Mustafa, 2019). The implementation of RBT Form 3 project helps teachers to foresee students' potential as it provides students with the opportunities to put forward their ideas and find solutions for the problem, they faced in completing the project. This hands-on, product creation approach is in-line with the concept of 21st century learning (Zulkarnain, 2012).

Effective teaching methods in RBT often incorporate hands-on experiences, collaborative projects, and digital tools. The integration of STEM (Science, Technology, Engineering, and Mathematics) elements within RBT has shown to enhance student engagement and learning outcomes (Idris et al., 2023). Despite its potential, several challenges hinder the full realization of empowerment through RBT education. Limited access to resources, insufficient teacher training, and outdated curricula often restrict the scope of technical skill development. Many schools are not equipped with the necessary tools, materials, and equipment to deliver the subject effectively. This deficiency limits the opportunities for practical, hands-on learning, which is crucial for student engagement and skill development (Sahaat, 2012).

Another challenge is the limited training of teachers. Teachers may not have received sufficient training in the RBT curriculum, particularly in the application of modern technology and software. This lack of training can hinder their ability to effectively teach the subject and inspire students to engage in the learning process (Endot, 2021; Ramli, 2017). Continuous professional development (CPD) programs to equip teachers with the latest pedagogical and technical competencies is needed to strengthen the teaching skills in STEM related subjects.

Additionally, there is limited student interest in the subject. Some students struggle to see the relevance of RBT to their future careers, making it difficult for teachers to motivate them. This lack of interest poses a challenge in fostering active participation and enthusiasm for the subject (Uyub, 2021). In addition, the examination-oriented culture in Malaysia's education system presents another obstacle. The strong focus on exams leaves little room for incorporating practical and project-based learning into the RBT curriculum. As a result, students are deprived of opportunities to develop practical skills and apply their knowledge to real-world problems.

To overcome these challenges, schools and educators can take several steps. These include providing adequate resources for hands-on activities, engaging and relevant learning experiences for students, promoting project-based learning, and providing support for students who may struggle with the language barrier. Based on the syllabus of RBT, there are approximately 30% of the RBT topics are related to Electrical and Electronics Engineering. Some of the related topics are introduction to electronics, electronic systems, digital electronics, microcontrollers, sensors and actuators and communication systems. By addressing these challenges, educators can help to ensure that RBT subjects are delivered effectively in the Malaysia school system.

Universities, particularly those with a background in electrical and electronics engineering, can play a critical role in enhancing the empowerment of knowledge and technical skills for RBT subjects among secondary school students in several ways. Universities can offer training and professional development programs for RBT teachers to help them stay updated with the latest technology and teaching methods.

This can enhance the quality of RBT education in schools and improve students' learning outcomes. In addition, providing resources and equipment to schools to help them deliver RBT subjects more effectively. This can include access to laboratories, workshops, and specialized equipment that may be too expensive for schools to purchase on their own. This can help students to understand the practical applications of RBT subjects and prepare them for future careers in these fields. Finally conducting research in RBT-related fields to advance the state of knowledge and to develop new technologies and teaching methods. This can help to improve the quality of RBT education in schools and to prepare students for the challenges of a rapidly evolving technological landscape.

Objectives

This study aims to enhance students' understanding of Reka Bentuk dan Teknologi (RBT) concepts, boost their engagement during RBT lessons, and improve their academic performance in RBT subjects, particularly within Electrical and Electronics

Engineering. Furthermore, it strives to foster a supportive learning environment that promotes effective RBT education. By leveraging the university's expertise in theoretical knowledge, hands-on experience, and technical skills, this initiative also seeks to support schools in delivering high-quality RBT education.

Methodology

This program aims to strengthen students' abilities in RBT subjects but also contributed to the broader mission of uplifting educational standards and supporting future generations in engineering and technological fields. The program progressed smoothly across five phases as demonstrated in Figure 1. The program was conducted over a period of approximately four months, with each workshop having a duration of three hours.

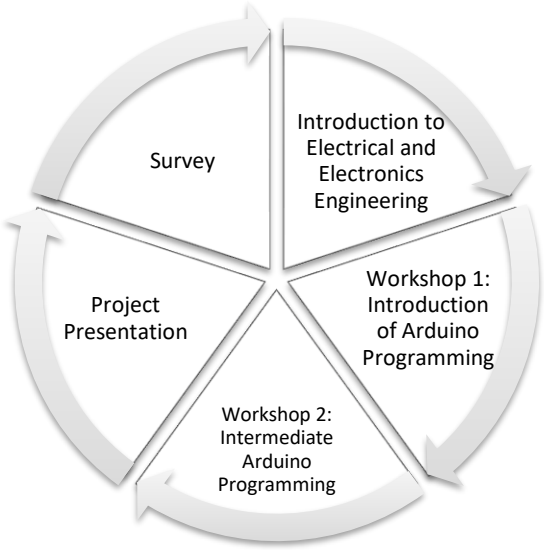

Figure 1: Program Flow

The workshop involved 64 students from SMK Saujana Indah, focusing on theoretical lessons in Electricity and Electronics (E&E), covering topics like circuits, power, voltage, and safety. These workshops were conducted by 3 lecturers, 2 researchers and assisted by 10 undergraduate students as facilitators. Phases 2 and 3 provided hands-on learning, where students were taught basic Arduino programming and circuit assembly using Arduino kits, along with conducting basic experiments. In Phase 4, students worked in groups to complete and present a project prototype, with the top 5 groups receiving "Best Project Awards."

Phase 1: Theoretical Concept of Electrical and Electronic Engineering (E&E).

Phase 1 includes a theoretical session on Electrical and Electronic Engineering (E&E) topics relevant to the RBT subject taken by Form 2 and Form 3 students. During this phase, students are introduced to foundational E&E concepts, including current, power, voltage, series and parallel circuits, as well as basic calculations and circuit connections. Additionally, the importance of safety when handling E&E components is emphasized.

Phase 2 & 3: Hands-On Session on Arduino

Phases 2 and 3 are hands-on sessions focused on programming and practical Arduino applications. Students learnt fundamental Arduino programming techniques and circuit assembly using the Arduino kit. These phases introduced students to the analog and digital input and output pins of the Arduino microcontroller. In addition, students participated in hands-on experiments with existing Arduino projects, gaining practical experience.

Phase 4: Project Presentation

The fourth phase is the closing phase, where students develop a project prototype and present their project outcomes. The students, divided into ten groups, had their projects evaluated by USM. Certificates and Best Project Awards were given to the top five groups. Additionally, ten Arduino kits were contributed to SMK Saujana Indah to inspire and sustain students' enthusiasm in Arduino programming. This initiative also supports ongoing STEM education at SMK Saujana Indah in Nibong Tebal.

Phase 5: Survey

To assess the program's effectiveness, a survey was conducted involving 64 students. Participants completed both pre and post-program online surveys through Google Forms. The pre-survey collected baseline data on students' existing knowledge, interest, and confidence in STEM topics, including their familiarity with Arduino and basic electrical concepts. Following the program, the post-survey evaluated changes in these areas, measuring growth in students' understanding, skills, and enthusiasm for STEM. This comparative analysis provided valuable insights into the program's impact and informed improvements for future sessions.

Results and Discussion

The study investigated the effectiveness of this program on students' understanding and hands-on skills development in RBT subject. It encompasses pre and post survey of the program.

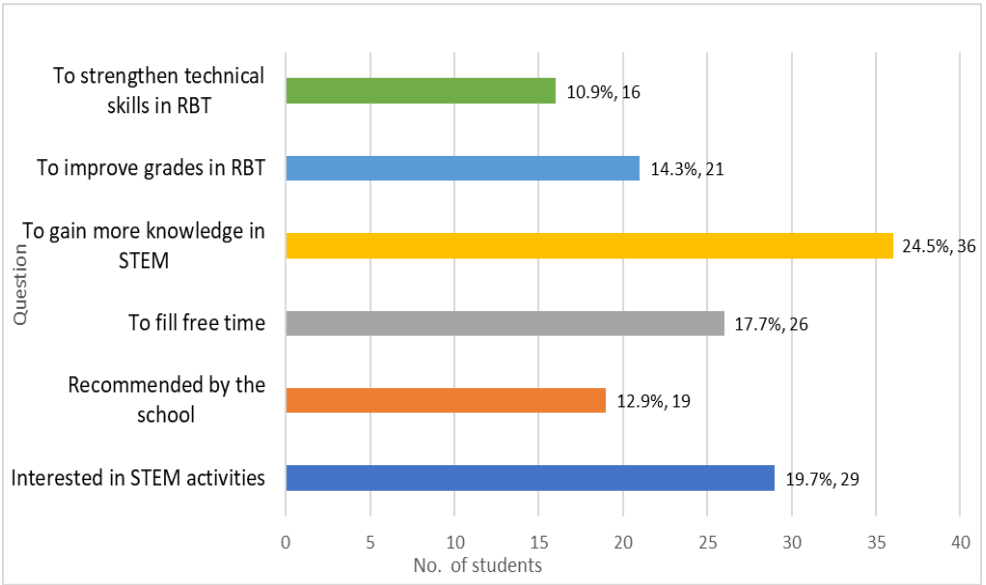

Figure 2: Motivations for Program Participation

Figure 2 presented the reasons for student participation in this program. It is observed that the highest motivations were gaining more knowledge in STEM (24.5%), followed by interest in STEM activities (19.7%). This indicated strong curiosity and passion for the field. Participation was also influenced by the desire to fill free time (17.7%) or to improve grades in RBT (14.3%), while 12.9% of students were encouraged by their schools. Strengthening technical skills in RBT was cited the least (10.9%). Overall, the data have shown participation was primarily driven by a desire to learn and explore STEM, with academic and institutional factors playing secondary roles.

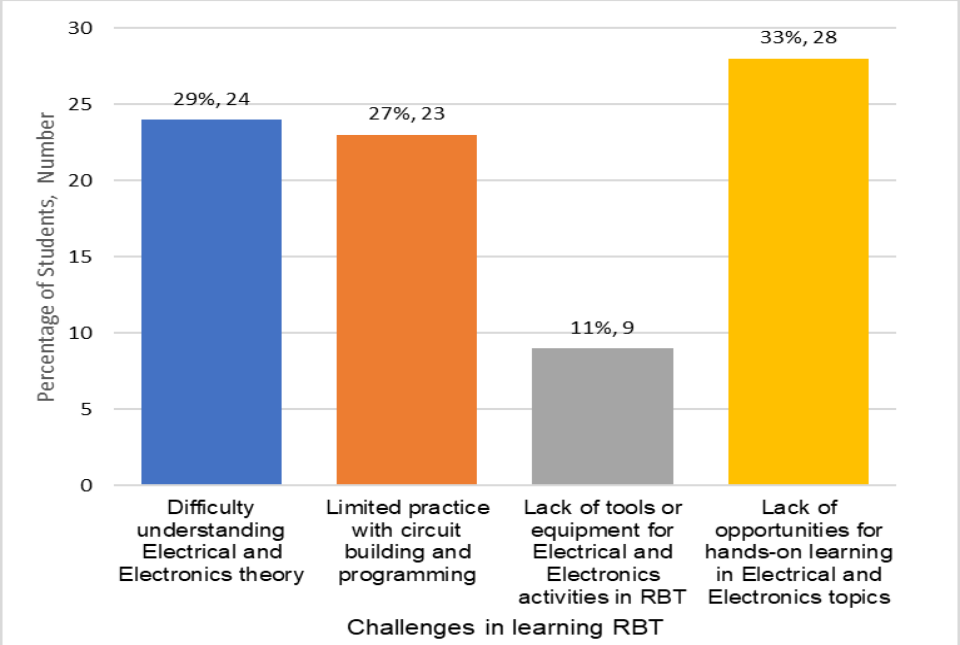

Figure 3: Challenges Faced in the RBT Subject

Figure 3 demonstrated the challenges students faced when learning RBT, especially in Electrical and Electronics topics. The biggest challenge, reported by 33% (28 students), was the lack of opportunities for hands-on learning. This shows that practical experience was crucial for understanding these subjects. The second most common issue, faced by 29% (24 students), is difficulty understanding Electrical and Electronics theory, suggesting that the theory might be too complex. Limited practice with circuit building and programming was also a challenge for 27% (23 students), showing that more hands-on exercises could help. The least mentioned challenge, reported by 11% (9 students), was the lack of tools or equipment for activities. Overall, these results highlight the need for more practical learning opportunities and clearer explanations of theory in RBT.

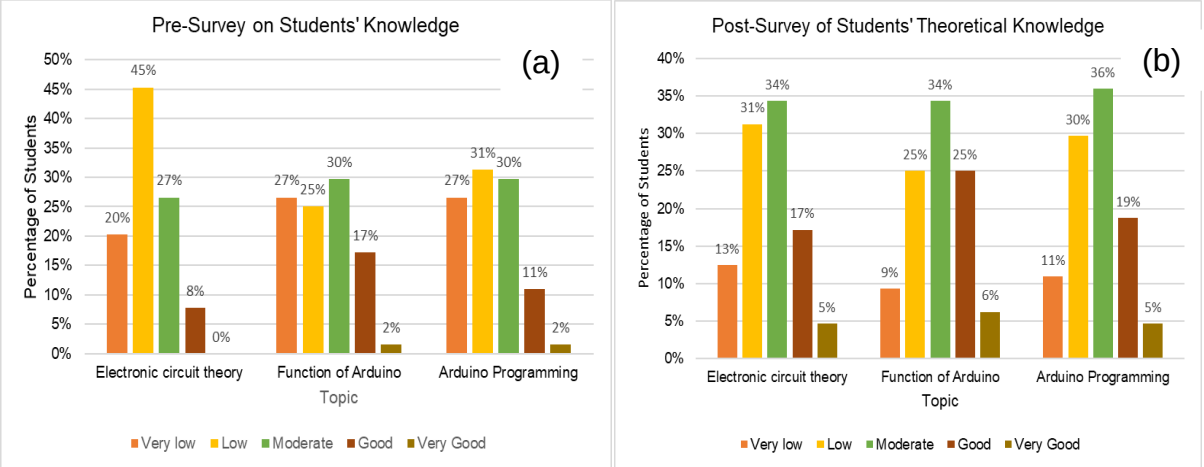

Figure 4: Pre and Post Survey of Students' Theoretical Knowledge Before and After Attending The Program

Figure 4 showed the comparison between the pre-survey and post-survey results showed significant improvements in students' knowledge across three key topics: electronic circuit theory, function of Arduino, and Arduino programming. In the pre-survey, a large percentage of students rated their knowledge as very low or low, with 65% of students reporting combination of low and very low knowledge in electronic circuit theory, followed by 52% (very low and low knowledge) for the function of Arduino. Similarly, 58% rated their knowledge in Arduino programming as very low and low. Only a small proportion felt confident, with just 27% and 30% rating their knowledge in electronic circuits and Arduino functions as moderate, respectively, and 8% and 17% marking them as Good. Meanwhile, 30% rated their knowledge in Arduino programming as moderate and 13% as good/very good.

However, in the post-survey, there was a clear shift, with more students reporting higher levels of understanding. The number of students rated their knowledge as very low and low decreased significantly across all topics, while those reporting moderate, good, and very good knowledge increased. Notably, Arduino Programming shown the greatest improvement, with a substantial rise in students rating their knowledge as good or very good, indicating a clear advancement in both theoretical understanding and practical application. Overall, the post-survey results reflected the effectiveness of the learning interventions, showing that students gained a better grasp of these topics after the instructional period.

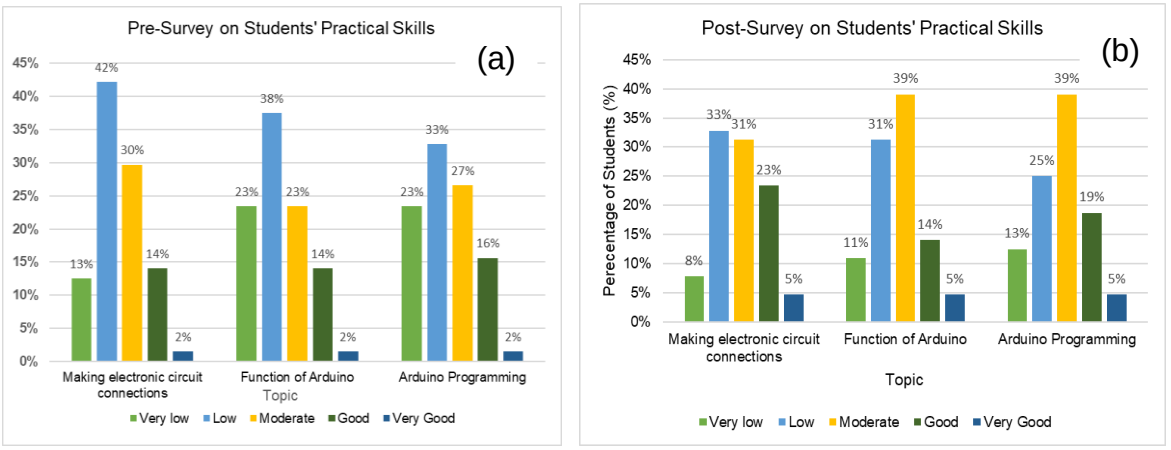

Figure 5: Students' Practical Skills (a) pre-survey and (b) post-survey

Figure 5 demonstrated the comparison between the pre-survey and post-survey on students' practical skills. These graphs revealed significant improvements in students' proficiency across all three areas: making electronic circuit connections, understanding the function of Arduino, and Arduino programming. In the pre-survey, the majority of students rated their skills as very low and low, with 55%, 61%, and 56%, respectively, indicating substantial gaps in confidence and competence. However, in the post-survey, these percentages dropped dramatically to 41%, 42%, and 38%, reflecting a marked reduction in students' perceived lack of skills.

In addition to the reduction in very low and low categories, there was a notable shift toward moderate, good, and very good skill levels. For instance, the proportion of students reporting good and very good skills increased from 16% to 28% in circuit connections, from 16% to 19% (remaining stable) for Arduino functionality, and from 18% to 24% in programming. Similarly, the moderate category experienced substantial growth, particularly for Arduino functionality and programming, where it rose to 39% in both cases. The improvements across all skill levels suggest the interventions or educational activities implemented between the surveys were highly effective in bridging skill gaps. Overall, the post-survey demonstrated a positive impact, showing that targeted training significantly improved students' practical skills. While progress is evident, there is still room for improvement, particularly in shifting more students to the good and very good categories, ensuring they achieve high levels of technical proficiency.

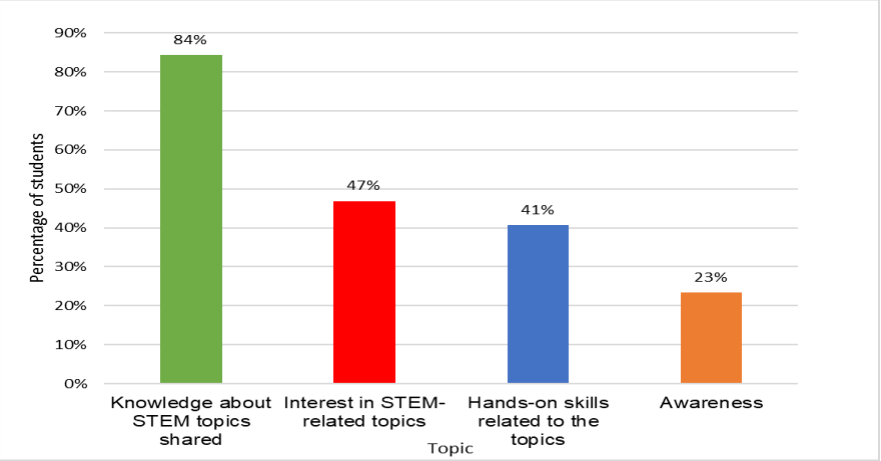

Figure 6: Topics Learnt from The Program

Figure 6 illustrated the topics covered and insight gained from the program. It is shown that 84% of students gained knowledge about STEM topics, reflecting strong informational exposure. However, only 47% of students were found to have expressed interest in STEM-related topics, revealing a gap between knowledge acquisition and enthusiasm. Additionally, 41% of students were reported to have developed hands-on skills in STEM areas, showcasing the practical application of learning, though this remains lower than the knowledge-sharing rate. Lastly, awareness of STEM-related topics was identified as the lowest at 23%, emphasizing the need for increased familiarity and engagement. These findings underscore the importance of strategies being implemented to bridge gaps between awareness, interest, and practical skills in STEM education.

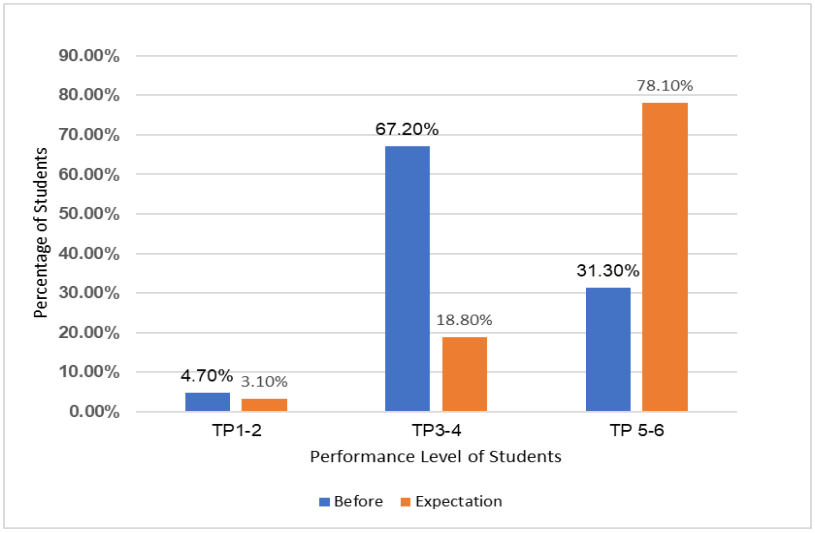

Figure 7: Performance Levels of Students in The RBT Subject Before and Student's Expectation After The Program

Figure 7 compared the performance levels of students in the RBT subject before an intervention (blue) and the expected performance after the intervention (orange) across three categories: TP1-2 (low), TP3-4 (moderate), and TP5-6 (high). Initially, 67.2% of students were in the moderate category (TP3-4), while only 31.3% achieved high performance (TP5-6), and a small percentage (4.7%) were in the low-

performance category (TP1-2). The expected performance levels show a significant shift, with 78.1% of students anticipated to achieve high performance (TP5-6) and a marked reduction in the moderate category (18.8%). The low-performance level (TP1-2) is expected to decline slightly to 3.1%. These results highlighted the intervention's potential to improve performance significantly, shifting majority of students into the high-performance category while reducing the proportion in the lower and moderate categories.

Conclusion

In conclusion, this paper demonstrated that the objectives of this initiative have been successfully achieved. The data clearly showed significant improvements in students' performance, with a notable shift from lower to higher performance levels. This indicated at the program has been effective in enhancing both knowledge and skills in STEM areas. The objectives of empowering students with practical, hands-on experiences and improving their academic achievement have clearly been met, as evidenced by the increase in students' high performance and the decrease in lower performance levels.

By providing students with both theoretical knowledge and technical skills, the program has bridged the gap between classroom learning and real-world application. While some challenges, such as raising awareness and fostering greater interest in STEM subjects, remain, the overall outcomes reflect the program's success. The findings suggest that the program has effectively achieved its aim of improving students' skills and knowledge in STEM and develop a greater passion for these fields. The continued success of such programs will be essential in ensuring that students are fully equipped for future challenges in STEM-related careers.

Acknowledgement

The authors would like to express their sincere appreciation to the USM University-Community Engagement 1001/ PELECT/AUPSE00236: STEM Program: Empowerment of Knowledge and Technical Skills in Design and Technology (Rekabentuk Teknologi-RBT) Subject among Secondary School Students for the financial support. The utmost appreciation also goes to SMK Saujana Indah, Nibong Tebal, Pulau Pinang for being the community partner in this program.

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