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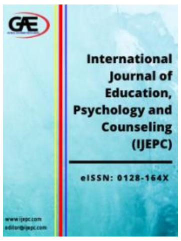

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EXPLORING THE IMPACT OF ROBOTICS PROGRAM IN ENHANCING STUDENTS' ATTITUDE TOWARDS SCIENCE

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Abstract:

The use of educational technology tools and program in education has been vital in Malaysia due to its benefits. Although many studies have proven these programs benefits for students' academic improvement, very less studies have focus on students' improvement towards attitude. Hence, the objective of this research was to explore the impact of robotics program in enhancing students' attitude towards Science. The study involved 474 10 years old students from the states of Selangor and Malacca, Malaysia. A quantitative research design was employed, utilizing a quasi-experimental approach with a control group and an experimental group using pre-test and post-test measurements. A questionnaire was administered to both the experimental and control groups to collect the necessary data. The collected data were analysed using Repeated Measures Analysis of Variance (ANOVA) test, with a significance level of 0.05, using SPSS 25 software. The results indicated a significant change ($\alpha \leq 0.05$) in the attitude towards science for the experimental group that received the robotics program, as compared to the control group.

Keywords:

Students' Attitude, Science, Robotics

Introduction

Teachers face ongoing difficulties in promoting active engagement and cultivating positive mindsets toward science within the present-day closely monitored educational setting.

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Buasuwan et al. (2022) highlight the importance of students' attitudes toward science as a critical skill to be developed in the 21st century. Nevertheless, Lowry-Brock (2016) notes that students who are perceived as more proficient by their peers often dominate classroom discussions, while those with weaker academic backgrounds tend to shy away from active participation. Previous research suggests that the integration of educational technology programs, such as robotics, can enhance student involvement and positively impact their conduct (Hirtz, 2020). Moreover, study from Chatzopoulos et al. (2022) has highlighted his finding on educational robot were encouraging, indicating a strong level of acceptance among the students and prospective teachers.

According to Kukard (2020), maintaining collaboration and engagement has posed significant challenges during the global pandemic, leading to a lack of acquisition of crucial 21st-century skills by students. LEGO-based Education introduces innovative technological tools that are in line with Bruner's theory, which is inspired by and adapted from the work of John Dewey. Dewey's focus emphasizes the importance of hands-on experiential learning (Parker & Thomsen, 2019). The LEGO Education approach involves the use of sets of blocks in various colors and sizes to construct tangible shapes and patterns. This enables students to engage in a concrete and experiential learning process. The objective is to promote active participation, cultivate motivation, and facilitate skill development in areas such as attitude towards science, problem-solving, and collaboration. Active engagement and participation of children in knowledge discovery and problem-solving are of utmost importance and essential in developing attitude towards Science, Technology, Engineering and Mathematics skills (Chatzopoulos et al., 2021). The approach employed by LEGO Education aligns with Bruner's theory and Dewey's emphasis on learning through practical application (Chu et al., 2017). Moreover, Kalogiannakis et al. (2021) has incorporated BBC micro bit programmable device to enhance primary students’ attitude towards computational thinking and problem solving and it has shown a positive outcome.

In Malaysia, the integration of educational technology programs has become a crucial aspect of education due to its favourable outcomes. The country has implemented several initiatives to nurture students' interest in science. In 2012, the Malaysian government introduced a range of programs and initiatives as part of the Science to Action (S2A) strategy, with the goal of promoting students' attitude towards science and achieving sciences to arts ratio of 60:40. However, despite dedicated efforts, these objectives have proven difficult to attain. Dato' Professor Dr. Noraini, the chairman of the National STEM Movement, emphasized that in 2020, only 19% of students in middle schools and higher education institutions were involved in STEM-related courses (Chonghui, 2020). Dr. Noraini stressed the significance of encouraging children to pursue these courses starting from primary school. This highlights a lack of enthusiasm and inclination among Malaysian students’ attitude toward science.

Numerous prior studies have concentrated on the effectiveness of robotics programs in enhancing students' academic achievements. However, insufficient attention has been given to assessing changes in students' attitudes after their participation in robotics programs. For instance, researcher Muhamad Shakir Bin Saad (2018) examined the efficacy of the robotics program in enhancing Matriculation students' performance in the Biology topic of Respiratory Cell. Given the scarcity of research addressing students' attitudes, the current study examines the impact of robotics programs on students' attitudes towards science.

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In order to obtain a thorough comprehension, the current study is guided by the subsequent research questions:

1. Does robotics program improve student's attitude towards science score for the experimental group?
2. Does conventional teaching method without robotics program improve student's attitude towards science score for control group?

Literature Review

The robotics design program integrates a variety of learning and behavioral theories, including constructivism theories proposed by Piaget and Vygotsky, Constructionism theory, Operant Conditioning theory, and Ajzen's Theory of Planned Behaviour. The robotics program itself is based on Piaget's theory of constructionism, which is a subset of constructivism. This approach emphasizes the importance of hands-on interaction with objects and events to foster understanding and develop scientific skills. Moreover, the program's challenges motivate students to repeatedly participate in tasks, facilitating the assimilation of information and knowledge. This repetitive behavior is believed to enhance the learning process, as supported by Kalyuga and Plass (2009).

This present study has also adopted Bers (2018) Positive Technology Development (PTD) framework. The PTD framework comprises six constructive behaviours: content creation, creativity, communication, collaboration, community building, and choice of conduct (Jurado et al., 2020). Hence, in this study, the PTD framework along with other pertinent theories were utilized to design a robotics program. Table 1 below has provided additional explanation regarding the application of these theories in the research:

Table 1: Theories Involved in Developing Educational Technology Robotics Program

INSTRUCTIONS	EXPLANATION	THEORY
The participants have been organized into smaller groups consisting of four students per group. Subsequently, the participants are required to collaborate in teams and engage in discussions on how to construct the designated robot.	- Collaboration within groups is crucial for students to accurately assemble the robot. - Students are required to divide their work in order to complete the task. - Integrating scientific and mathematical concepts is necessary for students to troubleshoot and repair the robot.	Social Constructivism Vygotsky's Theory Constructivism Piaget's Theory

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The SCRATCH coding was used to impart motion commands to the robot during each task. The students need to approach, based on mathematical and scientific principles, to determine the robot's specific movements.	- Active engagement in utilizing the SCRATCH coding software is required. Participants should possess basic computer literacy skills. - Students need to retain and apply the principles learned in science and mathematics.	Constructivism Piaget's Theory
The robot successfully reaches the finish line due to the accurate arrangement of programming blocks in the SCRATCH program.	- Robots are utilized to teach basic science and mathematics concepts.	Constructivism Piaget's Theory
In the event that the robot fails to reach the designated finish point, participants are required to repeat the process until the robot achieves success.	- If the student group's robot fails to advance to the next level, repetition or corrective measures will be implemented as a consequence.	Operant Conditioning Theory Ajzen's Theory of Planned Behaviour
The group whose robot arrives first will be recognized as the victorious team.	- Competition exists among participants within groups, fostering increased engagement and motivation for learning.	Ajzen's Theory of Planned Behaviour Theory of Constructionism
Every participant from each team will provide a response regarding the program.	- Evaluate the effectiveness of the program.	Vygotsky's Theory of Social Constructivism

While numerous prior studies have concentrated on evaluating the impact of robotics programs on students' academic achievements and diverse skills, there has been insufficient emphasis placed on assessing shifts in students' attitudes subsequent to their engagement in robotics programs. Educators primarily focus on promoting academic achievement in subjects by incorporating hands-on and technology-based learning modules, it is vital to prioritize the cultivation of students' attitudes as well. This is particularly important due to the limited research available on leveraging robotics to enhance attitudes, as highlighted by Papadakis (2022) and Tsakeni (2021). According to Papadakis & Kalogiannakis (2022), there is a lack of research examining its potential in fostering the development of students' attitude towards science and other 21st century skills although robotics is acknowledged as an interactive tool for enhancing skills. Therefore, this study aims to investigate the influence of a robotics program on students' attitudes towards science.

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Robotics Program

The integration of educational technology in the classroom has the potential to enhance students' access to instruction and alleviate feelings of social and academic isolation. This approach also encourages active participation in a wide range of academic activities and learning environments (Lynch et al., 2022). An example of such a program is the robotics program, which teaches students about the development, design, and construction of robots, as demonstrated by the research of Belmonte et al. (2021). This interactive and educational scientific tool enables children to cultivate their scientific mindset, foster creativity, and develop problem-solving skills, all while engaging in realistic scenarios, as emphasized by Shih et al. (2013).

In the contemporary era, teachers in many countries have been constantly exploring the integration of robotic activities as a means to enrich learning experiences in the fields of mathematics, science, and engineering (Hallak et al., 2019; Bratzel, 2005). Furthermore, the use of robotics in the form of educational games has gained significant traction in technology-based educational programs (Mee et al., 2020; Challinger, 2005; Arkin, 1998). By leveraging the mechanical and dynamic elements inherent in gaming processes, the educational system can inspire students, foster the development of 21st-century skills, and facilitate the exploration of information, as emphasized by Losup and Epema (2014). Rogers and Portsmore (2004) and Yang and Baldwin (2020) propose that robotics programs have the potential to enhance students' scientific and mathematical capabilities, as well as their overall behavior and 21st-century skills.

On other hand, Papadakis & Kalogiannakis (2019) has studied impact of a game-based methodology for teaching coding to pre-service kindergarten teachers by utilizing SCRATCH coding. Over a period of 13 weeks, students were introduced to the fundamental concepts of Scratch and subsequently tasked with creating their own projects. The projects were involved in designing interactive stories aimed at instructing preschool-age students on specific concepts related to mathematics or physical science. The author mentioned results obtained from the study has surpassed their expectations and were highly satisfactory. He also concluded the teachers believe that incorporating coding would boost their productivity, enhance their effectiveness, improve their job performance, and make their work more manageable. Additionally, it is noteworthy that students without prior programming experience acknowledged that SCRATCH coding had facilitated their learning of programming.

Moreover, the incorporation of robotics in the classroom not only enriches students' understanding of various subjects but also addresses their academic and social isolation, providing them with access to a comprehensive academic curriculum and diverse educational programs (Lynch et al., 2022). One particular program that aims to foster students' scientific mindset, problem-solving abilities, and hands-on skills in development, design, and construction is the robotics program (Belmonte et al., 2021). By utilizing this captivating and educational scientific tool, students can enhance their creativity and cultivate 21st-century skills by engaging in realistic scenarios (Shih et al., 2013). In the current study, the researchers employed the RoboBuilder RQ+110 robotic set, developed by a research group from South Korea, to implement the robotics program. This program included practical exercises such as assembling and disassembling robots, diagnose issues, and acquiring knowledge about creating robots based on scientific principles. The program was conducted for one hour as an after school program, with groups comprising three to four students.

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Attitude Towards Science

Science Attitude defined as individual's opinion of and disposition towards Science. Many studies have been conducted to explore students' attitudes towards Science. While Science educators acknowledge the significance of attitudes in learning, research findings regarding the impact of attitudes on students' academic achievement or interest in Science have yielded inconclusive results (Newell et al., 2015; Zacharia & Barton, 2004). Enhancing students' attitudes and fostering their enthusiasm for Science represents the initial step towards encouraging their pursuit of STEM fields beyond high school. Factors such as the school environment, ambition level, parents influence, and teaching quality among the key determinants influencing attitudes towards Science (Papanastasiou, 2004).

A plethora of studies (Gardner, 1975; Brown, 1976; Ormerod & Duckworth, 1975; Breakwell & Beardsell, 1992; Crawley & Black, 1992; Piburn, 1993; Tomperi et al., 2020) have identified numerous elements that contribute to assessing attitudes towards science. These elements encompass students' opinions of their science teacher, apprehension towards science, the value attributed to science, self-esteem regarding science, motivation in relation to science, enjoyment of science, attitudes of peers and friends towards science, attitudes of parents towards science, the classroom environment, achievement in science, and fear of failure in science courses.

The Ministry of Education Malaysia has implemented measures to equip students with 21st-century skills, specifically targeting the development of their scientific knowledge to enhance students’ attitude towards science. This objective is achieved through the adoption of revised syllabus, namely *Kurikulum Standard Sekolah Rendah (KSSR)* for primary schools and *Kurikulum Standard Sekolah Menengah (KSSM)* for secondary schools. The Malaysia Education Blueprint 2013-2025 underscores the significance of teachers engaging in self-improvement activities to enhance their teaching competencies in alignment with the demands of the 21st century (Mahanani et al., 2022; Ministry of Education, 2013). Additionally, the integration of technology into classroom instruction has become a crucial responsibility for educators (Rusdin, 2018; Amran & Rosli, 2017; Langworthy, 2013). Rahim and Abdullah (2017) propose that leveraging Information and Communication Technology (ICT) in pedagogy and teaching methodologies can inspire and support students in enhancing their communication skills, thereby excelling in 21st-century learning.

Therefore, this study utilizes attitude towards science as a means to augment students' comprehension of classroom content. This is achieved through open and honest discussions, constructive exchanges of differing viewpoints, and collaborative interactions during the weekly robotics program. Additionally, each member of the group demonstrates a willingness to assume various roles within the team, actively engaging and working together to solve problems using scientific concept and achieve common objectives throughout the robotics program.

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Methodology

Research Design

This is a quasi-experimental study where a quantitative approach was adopted to enhance the ecological validity of the research (Roger, 2019; Gill & Johnson, 2010; Mohd Majid, 2005). Data were gathered through questionnaires, where a set of instruments was used to collect information from the participants. The resulting data obtained in this study were in numerical format and subjected to statistical analysis. This methodology aligns with the recommendations put forth by Borgstede and Scholz (2021), Noyes et al. (2019), and Sugiyono (2017), who highlight the utility of quantitative research methodologies in addressing research problems by utilizing numerical data and employing statistical techniques. Additionally, a questionnaire was employed to assess the nature of the activity that has evolved into a communal practice.

Participant and Sampling Technique

To conduct this study, a purposive sampling method was utilized to select the sample, which is commonly employed when examining the effectiveness of interventions or programs (Bernard, 2002). This sampling approach offers the advantage of selecting participants who can provide valuable information, knowledge, or experiences (Sharma, 2017). The sample comprised 474 students from government schools in year 4, all aged 10 from Selangor and Malacca state. Among them, 294 students were assigned to the experiment group attended robotics program, while 180 students were the control group attended traditional learning methods. The participants were choosen based on criteria such as the student should have moderate to strong reading and comprehension abilities in order to successfully complete questionnaires. Additionally, they needed to maintain a good attendance record to ensure consistent participation in the researcher's program, minimizing instances of absenteeism.

Instrument & Tools

In this study, attitude towards science was measured using questionnaire Test of Science-Related Attitude (TOSRA) developed by Fraser (1981). TOSRA has seven dimensions that assess different components of attitudes towards science. Each dimension has 10 questions. Hence, students have to answer to of 70 questions in TOSRA by giving responses strongly agree, agree, not sure, disagree, and strongly disagree. Prior using this instrument, TOSRA has undergone a pilot test. The pilot test revealed Cronbach's alpha reliability coefficient for TOSRA questionnaire was 0.98 indicating the instrument is valid and appropriate for use in the present study.

Besides that, RoboBuilder RQ+110 robotic set was used throughout the robotics program. The provided kit enables students to build a total of 10 distinct robots and participate in coding exercises using the open-source platform SCRATCH. Comparable to the LEGO robots frequently utilized in educational settings, the RoboBuilder RQ+110 offers a cost-effective alternative while still providing a range of functionalities. Through the utilization of the SCRATCH programming language, which is commonly taught in schools, students are afforded the opportunity to acquire programming skills.

Study Procedure

The study was conducted for 12 weeks with week 1 is program briefing and pre-test, 9 weeks of intervention and 2 weeks encompass post-test 1 and post-test 2. Both the experimental and control groups will engage in regular classroom learning simultaneously. To ensure

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homogeneity within the sample, all students will take a pre-test using TOSRA questionnaire prior to the commencement of the program. Subsequently, the experimental group will receive the robotic program treatment after regular school hours, while the control group will attend conventional revision classes after school, focusing on the selected topics. The experimental group, students will partake in hands-on activities, including robot assembly, learning algorithms and pseudocode, and coding to solve assigned problems. At the conclusion of each class task, the trainer and facilitators will elucidate the underlying science principles. Conversely, the control group will receive traditional teaching revisions on science led by trainers, without incorporating robotics programs, on weekly basis for the duration of 12 weeks.

Data Analysis

The data obtained from TOSRA were analyzed with Statistical Packages for the Social Sciences (SPSS Version 25.0 for Windows). The comparison of mean scores of the pre-test, post-test 1 and post-test 2 between groups performed using a Repeated Measures Analysis of Variance (ANOVA) with a significance level of 0.05.

Results and Findings

The aim of this study was to examine how incorporating a robotics program affects students' attitudes towards science. To answer the research questions, descriptive analyses were conducted to assess the experimental and control groups separately. The control group had an average score of 3.1314 on the pre-test, while the experimental group had an average score of 3.0491. In the experimental group, there was a significant increase in the average score for post-test 2, reaching 3.8388. This indicates a difference of 0.7897 compared to the control group's average score of 3.1250, which represents a decrease of 0.0064. The results of the descriptive analysis demonstrate a notable improvement in the average scores of students in the experimental group across all three assessment points, while a decline was observed for the control group from the pre-test to post-test 2. The detailed findings of the descriptive analysis are presented in Table 2.

Table 2: Descriptive Statistics of Attitude Towards Science by Study Sample Group

Parameter	Control Group			Experimental Group		
	Pre	Post 1	Post 2	Pre	Post 1	Post 2
N	180	180	180	294	294	294
Mean	3.1314	3.1259	3.1250	3.0491	3.8251	3.8388
Standard Deviation	0.1415	0.1887	0.1922	0.9936	0.4373	0.4370
Minimum	2.94	2.93	2.91	2.74	3.00	3.03
Maximum	3.46	3.41	3.69	3.30	4.54	4.55

In order to determine the significance of the differences observed within the experimental and control groups, a Repeated Measures Analysis of Variance (ANOVA) was conducted with a significance level of $\alpha = .05$. The results of the analysis for the experimental and control groups can be found in Table 2 and Table 3, respectively. The outcomes of the ANOVA analysis demonstrate that the experimental group showed a significant result, with F (2, 103) = 8.15, p = .000, as displayed in Table 3. This value falls below the predetermined significance level of .05, indicating that the integration of the robotics program had a notable impact on the students' attitude towards science. In contrast, the ANOVA test conducted on the control group produced a non-significant result, with F (2, 50) = 2.18, p = .006, as indicated in Table 4. This value

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exceeds the designated significance level of 0.05. Consequently, it can be inferred that the control group, which underwent the conventional revision method without the inclusion of the robotics program as an after-school activity, did not demonstrate any improvement in their attitude towards science.

Table 3: ANOVA Test for Experiment Group

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
Intercept	Pillai's Trace	.406	127.28	1.00	52.00	0.00
	Wilks' Lambda	.594	127.28	1.00	52.00	0.00
	Hotelling's Trace	.684	127.28	1.00	52.00	0.00
	Roy's Largest Root	.684	127.28	1.00	52.00	0.00
Attitude Towards Science	Pillai's Trace	0.48	8.15	2.00	103.00	0.00
	Wilks' Lambda	**0.53**	**8.15**	**2.00**	**103.00**	**0.00**
	Hotelling's Trace	0.90	8.15	2.00	103.00	0.00
	Roy's Largest Root	0.90	8.15	2.00	103.00	0.00

Table 4: ANOVA Test for Control Group

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
Intercept	Pillai's Trace	.171	5.67	1.00	33.00	0.06
	Wilks' Lambda	.809	5.67	1.00	33.00	0.06
	Hotelling's Trace	.230	5.67	1.00	33.00	0.06
	Roy's Largest Root	.230	5.67	1.00	33.00	0.06
Attitude Towards Science	Pillai's Trace	0.40	2.18	2.00	50.00	0.06
	Wilks' Lambda	**0.51**	**2.18**	**2.00**	**50.00**	**0.06**
	Hotelling's Trace	0.72	2.18	2.00	50.00	0.06
	Roy's Largest Root	0.72	2.18	2.00	50.00	0.06

The results of the study have tackled research problem of the study and in line with Dato' Professor Dr. Noraini, the chairman of the National STEM Movement statement the whereby achieving 60:40 ratios of S2A policy, the students need to exhibit positive attitude towards STEM skills especially science since primary school (Chonghui, 2020). Besides that, hands on activity in this case robotics program has shown improvement in students' attitude towards science. The profile plots in Figure 1 and Figure 2 illustrate the effectiveness of the implemented robotics program in enhancing the students' attitude towards science within the experimental group and control group exhibited no improvement in this aspect.

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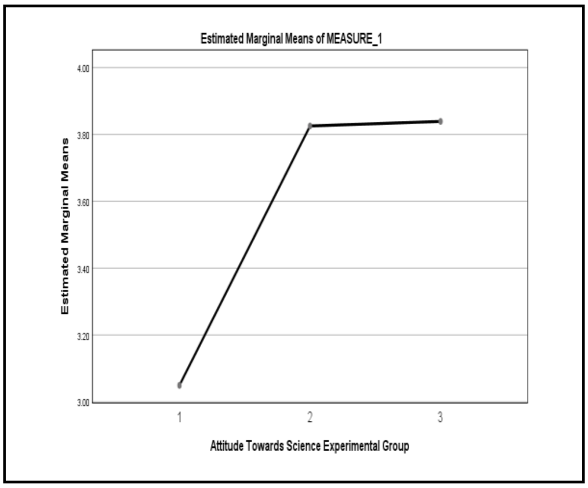

Figure 1: Profile Plot Experiment Group

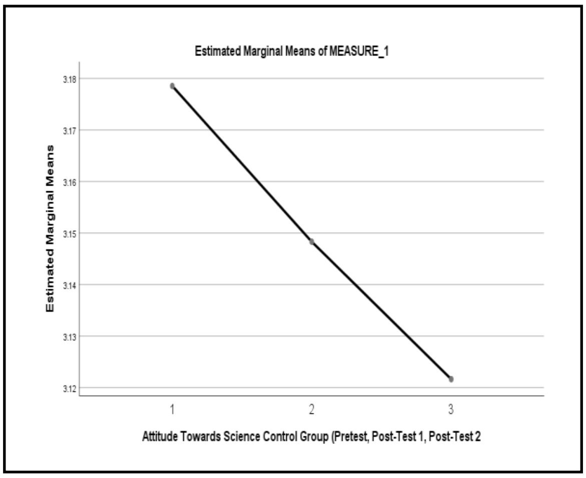

Figure 2: Profile Plot Control Group

Discussion

The findings of this study align with previous research conducted by Simões et al. (2013) and Kalogiannakis et al. (2021), which emphasized the role of gamification techniques, including the use of robots and interactive tools, in facilitating changes in behavior and attitude. These studies highlighted the importance of incorporating such techniques in interactions between students or between students and teachers. The results obtained in this study could be attributed to the requirement for students in the experimental group to apply their knowledge of science topics, such as simple machines in year 4, to successfully assemble and operate the robot. This hands-on approach likely contributed to improvements in their attitude. On the other hand, the control group, which relied on traditional teaching methods and lacked hands-on programs like robotics, did not exhibit a significant difference in attitude.

The integration of robotics program, has yielded positive effects on students' learning by enhancing motivation and promoting the development of 21st-century skills (Tsai et al., 2020). Moreover, it has contributed to an enriched learning experience (El Sadik & Al Abdulmonem, 2021). This approach to learning encourages active student engagement in constructing their own knowledge through scientific inquiry activities (Purba, 2021). By adopting this teaching method, an interactive learning environment is fostered, allowing students to acquire knowledge, apply it, and enhance their attitude towards science. Additionally, the incorporation of robotics programs has been found to be particularly engaging due to the competitive element it introduces (Danelid & Fältman, 2021).

Moreover, in our study, participants reported that the tasks in the robotics program became less challenging after they initially learned and completed the task of robot programming. These participants demonstrated a determined mindset, persisting until they either solved the problem successfully or identified any remaining errors. The experiment group students' also revealed this robotics program has been every joyful to learn as well as linking science and mathematics topics in syllabus when participating in the program. The introduction of robotics provided a unique experience for the participants, and the difficulties they faced helped them adapt, allowing them to gain relevant knowledge and develop 21st-century skills, particularly in attitude towards science.

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Conclusion

The findings of this study hold significant implications for various parties, including the Ministry, educator, and students, impacting areas such as research, practical applications, and educational models. The theoretical contribution of this study lies in its examination of the use of robotics programs as research models to enhance students' attitude towards science. The incorporation of robotics programs has played a crucial role in enabling interactive learning experiences and cultivating a positive change in students' attitude towards science. This research has also shown the feasibility of introducing robotics programs as an extracurricular activity in schools, with the aim of augmenting students' enthusiasm for STEM and promoting a favourable attitude towards it. Furthermore, this study aligns with the 21st-century learning model and the concept of technology-assisted learning, which, when effectively implemented, can positively influence students' attitudes towards education.

According to Che Noh and Abdul Karim's (2021) findings, conventional teacher-centred teaching approaches continue to dominate among educators, highlighting the necessity for a change in mindset that advocates for educational competitiveness. The findings of this study provide educators with essential knowledge to transition from a teacher-centred teaching approach to a student-centred teaching approach supported by technology. The anticipated outcome of this study is to enhance instructors' and educators' confidence in employing robot-assisted learning methods, thereby enabling the expansion of such programs to encompass additional behaviours and skills, particularly those aligned with 21st-century competencies.

Recommendation & Limitation

The present study has established a solid foundation for future practitioners, enabling them to further explore and investigate additional skills within the domain of robotics programs. It is recommended that future researchers consider exploring the readiness and acceptance of teachers in utilizing robots to enhance students' attitudes and the overall teaching process. Additionally, future studies could incorporate qualitative methods, such as teacher observations, interviews with parents, and interviews with students, alongside the quantitative approach employed in this study. Moreover, since the current study focused solely on primary school students, conducting similar research in suburban and rural secondary schools would be advantageous in assessing whether the findings align with or diverge from those of the present study. It is also recommended that future researchers explore the application of robotics programs to enhance language skills, including but not limited to listening, reading, writing, and grammar. Finally, it should be noted that the generalizability of the findings in this study is limited due to the small sample size. Therefore, the results should be interpreted within the context of the questionnaire used, the specific location of the study, and the conditions under which it was conducted.

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