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Meta-Analysis study: The influence of STEM education on student attitudes

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A. Conception and design of the study
B. Acquisition of data
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Abstract. In STEM education, science, technology, engineering, and mathematics elements have been woven together to enhance students' creativity and critical thinking (Mazlini Adnan et al., 2016). The implementation of STEM training is in line with the Ministry of Education Malaysia's (MOE) objective of becoming one-third in the TIMMS (*Trends in International Mathematics and Science Study*) and PISA (*Programme International Student Assessment*) as specified in the Malaysian Education Development Plan (PPPM 2013-2025) by the year 2025. Therefore, many studies have been conducted locally and abroad related to STEM education. The studies also focus on a particular aim in discussing the findings. This meta-analysis study was conducted to examine three aspects studied in each selected research. The findings indicate that these studies meet the requirements in helping to improve students' attitudes towards STEM implementation. In turn, the implications of this study will assist subsequent researchers in determining the focus of their further study.

Keywords: Meta-analysis, critical and creative thinking, STEM education, attitude.

INTRODUCTION

STEM is derived from the acronym of science, technology, engineering and mathematics. STEM education has begun to be practised by many countries in the world in their education systems. In Malaysia, the STEM education plan is one of the aspirations that has already begun to be expressed in PPPM 2013-2025. STEM education has been enshrined in the first shift to provide equal access to international-quality education. This is because numerous researchers recognise STEM in the improvement of student attitudes.

Furthermore, STEM education has been found to encourage students to think at a higher level and successfully produce an engineering design in solving problems in daily life (Dearamae et al., 2021). Creating is the highest level in the Revised Bloom's Taxonomy (2001). However, the Ministry of Education Malaysia has identified that the lack of awareness about STEM is among the factors contributing to the decline in student involvement in STEM. The students also considered STEM subjects difficult to understand (PPPM 2013-2025, 2013). This has made studies on STEM education and student attitudes important to be conducted (Matsuura and Nakamura, 2021).

Many researchers have been interested in studying the influence of STEM on student attitudes, both within and outside Malaysia. STEM has been recognised to improve students' attitudes in learning science and mathematics. Kamisah Osman et al. (2007) have defined attitude as a process of mental preparation that is independent and organised based on experience to produce a response to received stimuli. For example in Project-Based Learning (PBL) requires students to integrate with peers and teachers to produce a project. Students are more positive about the implementation of PBL because they are free to discuss with friends and teachers, indirectly encourage them to use high-level thinking skills.

The objective of this study was to identify the influence of STEM education on student attitudes based on ten studies in the last five years. The researcher has examined three aspects, namely (1) the methodology used, (2) the respondents involved and (3) the main findings of the study.

METHOD

This study uses a meta-analysis design, a secondary study form, identifying, exploring, and interpreting all relevant studies related to a topic domain (Webster and Watson, 2002). One database has been selected to narrow down the scope of previous research on science, technology, engineering, and mathematics (STEM) education in Malaysia, namely Google Scholar. This database was selected because it could increase the chances of finding relevant literature. Keywords such as "*Pendidikan STEM DAN sikap pelajar*" (in Malay) or "STEM education AND student attitude" were used to search the article. Among the criteria for selecting articles to analyse are (i) research in the field of STEM education; and (ii) research data collected among schools; (iii) the latest 5-year interval. Finally, a total of ten articles were identified that meet the set criteria. Table 1 shows a list of research articles related to student attitude and STEM education that have been systematically analysed to answer predefined research questions.

Research Questions:

1. What is the research methodology in the researches on the influence of students' attitudes towards STEM education?

2. Who are the respondents involved in the researches on the influence of students' attitudes towards STEM education?
3. What are the main findings in the researches on the influence of students' attitudes towards STEM education ?

Table 1. Selected articles for STEM education and student attitude

Researchers	Journal/Proceedings/ Issues	Title	Year
Imaduddin and Warih	International Journal of Contemporary Educational Research, vol. 8, no. 1, pp. 14-26.	Students' Attitude toward STEM Project-Based Learning in the Fun Cooking Activity to Learn about the Colloid System.	2021
Admawati and Jumadi	Journal of Physics: Conference Series, SEA-STEM 2020.	The impact of STEM PjBL on students' engineering practice, scientific practice, and scientific attitude.	2021
Fern and Mohd Matore	Jurnal Dunia Pendidikan, vol. 2, no. 3, pp. 72-81.	Students' Attitudes Towards the Implementation of Science, Technology, Engineering and Mathematics (STEM) in Learning.	2020
Timur et al.	Journal of Theoretical Educational Science, vol. 13, no. 2, pp. 334-351.	Attitudes of the Students Attending Out-of-School STEM Workshops towards STEM Education.	2020
Kurt and Benzer	Journal of Science Learning, vol. 3, no. 2, pp. 79-88.	An Investigation on the Effect of STEM Practices on Sixth Grade Students' Academic Achievement, Problem Solving Skills, and Attitudes towards STEM.	2020
Amirah Abdol Rahaman et al.	International Conference of Research and Education for Educators (ICREE) 2019, 9th & 10th December 2019, Phuket, Thailand.	Attitudes Towards STEM Careers In Sarawak Rural Secondary Schools.	2019
Choiriah	Master thesis, Universitas Islam Negeri Raden Intan Lampung, Indonesia.	The Effectiveness of STEM Learning (Science Technology Engineering And Mathematics) Towards Scientific Attitudes and Understanding of Students' Concepts.	2019
Fazilah Razali et al.	International Journal of Academic Research in Business & Social Science, vol. 8, no. 5, pp. 962-976.	Students Attitude towards Science, Technology, Engineering and Mathematics in Developing Career Aspiration.	2018
Vennix et al.	International Journal of Science Education, vol. 40, no. 11, pp. 1263-1283.	Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM?	2018
Suprapto	Journal of Turkish Science Education, vol. 13, no. Special Issue, pp. 75-87.	Students' Attitudes towards STEM Education: Voices from Indonesian Junior High Schools.	2016

RESULT

1. What is the methodology of STEM education studies?
   From the analysis of the study, the researchers have used a quantitative approach in the form of survey and quasi-experimental. Only three out of ten studies use a quantitative approach in the form of quasi-experiments, namely studies by Admawati

and Jumadi (2021), Kurt and Benzer (2020) and Choiriah (2019). Meanwhile, seven other studies use a quantitative approach in the form of surveys.

2. Who are the respondents involved in STEM education studies?
   In this study, the researchers used high school students as respondents.

Table 2. Types of respondents involved in studies

Researches	Types of Respondents
Imaduddin and Warih (2021)	101 SMA student in Negeri 1 Kudus, Indonesia.
Admawati and Jumadi (2021)	70 eight grade secondary school students in Yogyakarta.
Fern and Mohd Matore (2020)	34 form two students in Kuching, Sarawak.
Serkan Timur et al. (2020)	170 students are ranging between 7 and 14 years old in Turkey.
Kurt and Benzer (2020)	26 sixth-grade students from Cankiri province in Turkey.
Amirah Abdol Rahaman et al. (2019)	159 form two students in Kapit, Sarawak.
Choiriah (2019)	57 students in SMAN 1 Semende Darat Laut, South Sumatra.
Fazilah Razali et al. (2018)	398 form four students in Selangor.
Vennix et al. (2018)	729 secondary school students in the United States and the Netherlands.
Suprapto (2016)	260 secondary school students in East Java.

Based on Table 2 above, three studies involved school students in Malaysia, four studies involved students in Indonesia, two studies involved students in Turkey, and one study involved students in two countries, the United States and the Netherlands. Next, all ten studies involved secondary schools. In addition, all these studies only involved students from non-examination classes, namely, Form Two and Form Four students.

3. What are the main findings in STEM education studies ?.
   From the review of the above studies, the study's main findings are stated in Table 3 below.

Table 3. The main findings of the study

Research	Main Findings
Imaduddin and Warih (2021)	1. The average score of each attitude item was higher in (1) the women's group, (2) the group that was accustomed to cooking, (3) the group that had passion, (4) the group that had goals, and (5) the group that had a perception that high against gender. 2. The attitude values in the group of students did not differ much; except that the group with interest in the culinary field had a higher average score than the group with no interest. 3. The level of understanding of students is not closely related to attitudes.
Admawati and Jumadi (2021)	STEM PjBL impacts science, engineering and science attitudes among pupils.
Fern and Mohd Matore (2020)	1. There are significant differences between male and female students on students' attitudes towards implementing STEM in learning. 2. The introduction of STEM has shown male pupils to be more optimistic than female students.

Serkan Timur et al. (2020)	1. STEM workshops outside of school cause students' attitudes towards STEM to improve. 2. Students' STEM attitude scores do not differ by gender. 3. There are significant differences in the engineering sub-dimensions in the scale of STEM attitudes towards mothers' educational status. 4. According to the father's education status, students' STEM attitude scales did not change. 3. Semi-structured interviews revealed that students were not well aware of STEM education and concluded that their attitudes had a beneficial impact on accomplishing specific results.
Kurt and Benzer (2020)	1. Academic Achievement Test scores of the experimental group receiving STEM practice were higher than the control group using the included constructivist method. 2. There was a difference between the post-test scores of the STEM attitude scale, STEM Career Interest Survey, and Inventory Problem Solving on the experimental and control groups.
Amirah Abdol Rahaman et al. (2019)	Students' attitude towards STEM careers is at a moderate level. The mean value for Technology and Engineering is 3.56, Mathematics 3.54 and Science 3.48.
Choiriah (2019)	1. There is a difference between students' academic attitudes and conceptual understanding of STEM learning approaches and conventional learning. 2. There is a difference between students' conceptual understanding of STEM learning approaches and conventional learning. 3. There is a difference between academic attitudes towards the use of STEM learning approaches and conventional learning.
Fazilah Razali et al. (2018)	1. Students' attitudes in developing STEM careers recorded a value of p = .002 and significant with a value of p <.05. 2. Influence for three sub-constructs of attitudes towards STEM, namely science (0.65), technology and engineering (0.65) as well as mathematics (0.59).
Vennix et al. (2018)	The outreach activities learning environment successfully increases student motivation in STEM and attitudes toward STEM.
Suprapto (2016)	There is a significant relationship between the dimensions of attitudes towards STEM.

DISCUSSION

Many studies have proven that STEM education influences student attitudes. Researchers have studied the implementation of Project-Based Learning (PBL) on students' attitudes (Imaduddin and Warih, 2021; Admawati and Jumadi, 2021). This is due to students' increased interest in active learning methods such as PBL. Activities in PBL allow them the freedom to think creatively (Mohd Saifulkhair Omar and Mohd Isha Awang, 2021).

Furthermore, the study also found that students' attitudes influence careers in STEM (Amirah Abdol Rahaman et al., 2019; Fazilah Razali et al., 2018). The influence of attitudes towards STEM was strong for all four subjects in STEM, with the lowest subject being Mathematics (0.59). Meanwhile, the mean value of attitude for technology and engineering is 3.56, Mathematics, 3.54 and Science, 3.48. Technology and engineering are some of the fields that require high knowledge and skills.

In addition, outdoor learning improved student attitudes (Vennix et al., 2018; Serkan Timur et al., 2020). Students prefer learning that does not require them to be in a formal

classroom. This is because the arrangement of positions in the classroom will limit the interaction between students and teachers. Fern and Mohd Matore (2020) discovered a substantial difference in male and female students' attitudes on gender, with male students having more favourable sentiments than female students. Male student are more engaged in learning that involves a greater amount of activity than learning in a formal classroom which causes them to have to be in the same position all the time.

Quasi-experimental studies conducted by Admawati and Jumadi (2021), Kurt and Benzer (2020) and Choiriah (2019) had strengthened the claim that STEM learning approaches successfully improve students' positive attitudes compared to conventional learning approaches. The focus of STEM education is to encourage students to create inventions that aim to solve everyday problems. Creating is the highest level in Bloom's Taxonomy (2001).

CONCLUSION

STEM education has influenced students' attitudes in learning as it is one of active learning. Active learning involves students in activities planned by the teacher. Students will be allowed to express their ideas in their STEM activities. Active learning has successfully improved student performance in STEM (Freeman et al., 2014).

However, fewer studies are conducted in Malaysia than in Indonesia on the influence of attitudes towards STEM Education. Despite that, research on STEM education has attracted many foreign researchers who have studied various teaching methods as research factors. Students of Generation Z prefer learning techniques and instructional aids based on cutting-edge technology rather than rigorous approaches. They would rather provide thoughts than accept consistent facts.

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