

Arts Element in STEAM Education: A Systematic Review of Journal Publications

See Too Kay Shi

kayshiseetoo@gmail.com

Universiti Malaysia Kelantan

Ng Siew Foen

siewfoen@umk.edu.my

Universiti Malaysia Kelantan

ABSTRACT

Most countries have conducted research in the last few years to improve their students' achievement through STEAM which means science, technology, engineering, arts, and mathematics education. Anyway, in Malaysia STEM education still focus in both primary and secondary schools. This was stated in the Malaysian Education Blueprint (2013-2015) in which STEM education would strengthen the science subjects in our country. However, the main issue related to STEM education in Malaysia is students' lack of interest in science subjects. The factors that contribute to students' lack of interest in STEM are students' anxieties and difficulties in getting good grades in STEM, declining PISA performance, and teachers' teaching approach. Many studies that show integrating arts in STEM, which is known as STEAM education, is a critical education model for enhancing STEM. The United States, Korea, and New Zealand have already implemented the model in their education system. This literature review aims to introduce the STEAM framework and its importance for students and teachers. It examines the findings, discussions, and recommendations of collected STEM/STEAM research works from 2006 to 2021 based on positive impact of STEAM on students' achievement, cognitive development, creativity, and ability in problem-solving. STEAM education is still new in Malaysia and if it were to be implemented in Malaysia, policymakers will need to develop a curriculum, professional development for teachers, and materials to ensure that it can be implemented successfully in Malaysia.

Keywords: Arts Element; STEAM; STEM education; Malaysian Education Blueprint; develop a curriculum

INTRODUCTION

In recent years, many countries have conducted research to improve STEM (science, technology, engineering, and mathematics) education in order to improve student achievement. STEM education has received significant official and institutional backing in the United States and the European Union (Corlu & Aydin, 2016). Malaysia is now emphasizing the importance of STEM education. To strengthen science topics, the Malaysian government has declared STEM education as a priority in the Malaysia Education Blueprint (2013-2025). During the 2017 KSSM and KSSR curriculum modifications, STEM was incorporated into the formulation and implementation of

new curricula. STEM approaches including high-order thinking abilities, inquiry-based learning, problem-solving, contextual learning, collaborative learning, and project-based learning and they are applied in the classroom in both secondary and primary schools. Despite the attention that is given to STEM education, there is still an ongoing debate about students' lack of interest in STEM. Students' lack of interest in pursuing their studies in science-related programs can be seen in the following findings. Research by Yang (2010) found that only five percent of students in the United States of undergraduate level pursue their studies in science-related programs. When children entered secondary school in England, their interest in science topics began to wane (Barmby et al., 2008). In Malaysia, according to Faizatul (2020), only 19% of 44700 Pentaksiran Tingkatan Tiga (PT3) candidates were joining the science stream in form four. The Ministry of Education (2019) science stream students in the year 2018 decreased from 48% in 2012 to 44% in 2018. Currently, the target to achieve a ratio of 60:40 in the science stream is still far from the target.

According to Faizatul (2020), the reason for students' lack of interest in STEM was because they were anxious due to the perception that it was too difficult to get good grades in STEM subjects such as physic, chemistry, and Addition Mathematics. As Amelia et al. (2019) so eloquently put it, the diminishing number of academics in the science stream is due to fear and a lack of faith in STEM-related subjects. This is because they believe the science stream has a more demanding syllabus than the opposite stream. If the current trend continues, Malaysia will face a scarcity of STEM workers in the future (Abdullah et al., 2017). According to Ring (2017), students have the notion that pursuing postsecondary education is tough if they pick STEM-related fields. Negative attitudes about STEM have been a deterrent to kids pursuing STEM careers (Sin, 2013).

Similarly, PISA results in 2018 have become a significant factor in the gradual decline of science stream pupils. According to (Barrett et al., 2015), STEM learning in the United States has declined in comparison to Chinese scholars' performance. Furthermore, despite the rapid rise of science and innovation, student interest in STEM topics has declined dramatically. According to the National Assessment of Educational Progress (NAEP), around 70% of Grade 8 pupils in the United States were not proficient in mathematics in 2018. Malaysia's PISA results in STEM are similarly not encouraging. . Malaysia's PISA results in STEM are similarly not encouraging. In Malaysia, PISA scores in STEM are similarly not encouraging. Malaysia had been in the bottom two-thirds of the list of all participating countries. Malaysian students get 440 points on average in Mathematics, compared to 489 points in OECD countries. Similarly, Malaysian students earn 438 points in science, compared to an OECD average of 489 points. According to Suraya Bahrum et al., (2017), students' interest in STEM has waned, and their STEM achievement is very low.

Teachers have a critical role in the success of STEM education combined with other subjects. One of the factors for students' lack of interest in the STEM field is because of teachers are not exposed to multidiscipline teaching methods (Mohamad Hisyam, 2019). Teachers lack exposure and training in the integrated STEM teaching approach so that STEM has left many teachers with outdated knowledge in science and mathematics (Rahman et.al, 2017). When requested to teach STEM in the classroom, teachers, according to Wei (2020), are less confident and concerned. This is due to the fact that they have never received professional training in teaching STEM subjects. As a result, the teaching quality of teachers in regards to STEM education was judged to be moderate. As can be observed, teachers' attitudes, methodology, and preparation in STEM education were all significant variables in students' interest in STEM. Besides that, Kim (2018) stated that teachers' workload had caused ineffective teaching performance among science teachers. Teachers do not have enough time to teach using 21st-century skills such as problem-

solving, collaborative learning, or project-based learning. They need to prepare students for exams so all the teachers are preferring to use the traditional approach in teaching (Titik Rahayu, 2018). The traditional teaching approach will affect students' interest in STEM.

STEM is seen as the means to achieve economic growth; policymakers and researchers have expressed concerns about the issues discussed. As a result, this study introduces arts in STEM which is known as STEAM education, and the importance of STEAM that can help the Ministry of Education to increase students' interest in science subjects and improve teacher teaching skills.

METHODOLOGY

This study examines the findings of STEM education research publications as well as current literature from 2006 to 2021. Using a content analysis technique, it analyses and synthesizes the findings, conclusions, discussions, and ideas of accumulated research works connected to STEM/STEAM education. This study helps students to comprehend the STEAM framework and act as a guide for the creation of a tutorial program in Malaysia.

Integrating Arts in STEM

Programmers, system engineers, IT professionals, biotechnologies, project leaders, and other occupations related to high technology are in high demand in today's digital society and economy. Many countries recognize the value of the arts. Recognizing that "humanities design and creativity are critical underpinnings of effective mathematicians, scientists, and engineers," Canada and Australia established the Humanities Design and Creativity Initiative (Herro et.al., 2018). The United States and Korea want to boost students' interest, engagement, motivation, and value in STEM education by incorporating aesthetic elements (Moomaw,2012). Arts play a vital role in the development of informed and well-rounded citizens. For young children, early exposure to STEAM offers various benefits. Integrating and engaging learning experiences boost students' enthusiasm in learning to interact with pupils in STEM education, Malaysian education requires a STEAM learning approach. STEM integrated with the arts gives the variety and unpredictability required for new product development and design (Oner et al., 2016).

In terms of schooling, including arts into STEM can help students develop their problem-solving skills while also revealing their creativity, resulting in their producing artistic products from a holistic and positive perspective. Houet (2020) emphasized that arts are vital to STEM because STEAM can educate citizens capable of discovering and investigating links among STEM subjects and other areas, such as activities in life, to deal with the issues of the twenty-first century. There are major downsides in communication, cooperation, innovation, and important thinking benefits, according to Ayvaci & Ayaydin (2017) and Gulhan & Sahin (2018). Students may also be more prepared to learn by exploring and experimenting, and by combining traditional STEM with the arts, they may be able to maximize interaction with their surroundings. STEAM could be a way to take benefit of STEM while also incorporating these guidelines into and through the humanities. STEAM elevates STEM by allowing students to relate their learning to principles and standards, providing them access to the entire learning palette. Limitations are replaced by amazement, critique, inquiry, and innovation in STEAM.

STEAM Education

Science, Technology, Engineering, Arts, and Math (STEAM) are acronyms for Science, Technology, Engineering, Arts, and Math. Georgette Yakman may have been a founder of STEAM when she was a master's student in Virginia Polytechnic and State University's Integrated Science-Technology-Engineering-Mathematics Education programme in 2006 (ISTEMed). The STEAM Congressional Caucus, which stands for Science, Technology, Engineering, Arts, and Mathematics, was formed in January 2013. The Caucus' mission is to "change educational vocabulary to reflect the benefits of both the humanities and sciences, as well as their intersections, to future generations of Americans."

Yakman (2008) STEAM is based on STEM education, which is a relatively new paradigm for teaching across disciplines to help more students comprehend the systems and relationships that combine hard sciences, technology, engineering, and mathematics to help address problems in a quickly changing world. The STEAM framework tries to help educators teach subjects in a way that is more connected to one another. Within the already well-established sphere of education, STEAM-style teaching is frequently fun and meaningfully offered in further engaging and deeply embedding methods. Students require a functional literacy that includes a breadth of first-discipline literacy, as well as the capacity to transfer knowledge with higher-order thinking between disciplines (DeBoer, 1991; Yakman, 2008). The STEAM ideology revolves around the idea that STEAM stands for Science, Technology, Engineering, and the Humanities, which is backed by Mathematical aspects (Yakman, 2008). The following are definitions and classifications of STEAM elements:

- Science: "What exists naturally and the way it's affected?"
"Physics, Biology, Chemistry, Geosciences, Space Science & Biochemistry"
- Technology: "What is human-made?"
"Nature of Technology, Technology, and Society, Design, Abilities for a Technological World, The Designed World (including Medical, Agriculture & Biotechnology, Construction, Manufacturing, Information and Communication, Transportation, Power & Energy"
- Engineering: "The use of creativity and logic, based in mathematics and science, utilizing technology as a linking agent to create contributions to the world."
"Aerospace, Architectural, Agricultural, Chemical, Civil, Computer, Electrical, Environmental, Fluid, Industrial/Systems, Materials, Mining, Naval Architectural, Nuclear, Ocean (ASEE, 2008)"
- Mathematics: "Numbers and Operations, Algebra, Geometry, Measurement, Data Analysis & Probability, Problem Solving, Reasoning & Proof, Communication, (including Trigonometry, Calculus & Theory)" (NCTM, 1989)
- Arts : "How society develops, impacts, is communicated and understood with its attitudes and customs in the past, present, and future." "Physical, Fine, Manual, Language

Discipline-Specific Level

"The fourth level of the pyramid is labeled the discipline-specific level. This level is where the specific divisions of each silo are given an overview. This is the level where experts will explore what areas of expertise, they wish to acquire a career and hobby. Since this is very appropriate for young adults and most relevant to secondary education."

Content-Specific Level

"The fifth level of the pyramid is the content-specific level. Specific content areas are studied in detail, where professional development happens and students delve into the tighter realm of the specific content areas of their choice. Areas can be studied alone or in specifically grouped clusters from within their silos or from across the fields"

Yakman argues contextual learning is a STEAM strategy in which students are invited to comprehend events that occur in their immediate environment (Ridwan et.al 2017). STEAM education encourages students to explore, solving problems with their abilities, collaborating, and communicating with others when they involve with the learning processes.

A working definition from the Office of Congresswoman (Bonamici.S, 2014):

STEAM: "the integration of arts and design principles, concepts, and techniques into STEM instruction and learning, achieved through the use of arts integration curriculums, collaboration with qualified teaching artists, community-based arts organizations, and art teachers employed by LEAs (Local Education Agencies), and other teaching methods that use the arts to facilitate an effectively carry out STEM instruction and learning."

Julia Andrew (2020) STEAM characteristics can be concluded as:

1. STEAM is an integrated learning method that necessitates a deliberate link between standards, assessments, and course design/implementation.
2. True STEAM experiences entail teaching and assessing two or more standards from Science, Technology, Engineering, Math, and the Arts through each other.
3. The STEAM approach is built on inquiry, collaboration, and a focus on process-based learning.
4. A true STEAM project must utilize and leverage the integrity of the arts itself.
5. Intentional connections-students can demonstrate and apply their talents; 5 STEAM outcomes: Inquiry-based learning is built on questions, problem-solving, and the process of learning. Integrity- the substance of the arts is chosen and is being taught with honesty; Collaboration, Creativity, Critical Thinking, and Communication are 21st-century skills; Equitable Assessment is a measurement of growth.

Julia Andrew is a character in the film Julia Andrew (2020) The STEAM education framework represents a paradigm shift from the old educational philosophy, which was centered on mono

disciplinarity, to modern requirements, which emphasize multidisciplinary. Integrating the arts into STEM benefits students by fostering creativity and learning via hands-on experience inside the STEM environment.

Findings

Importance of STEAM

Impacting students' achievement

STEAM is an approach to positively impacting student performance (Brouillette, L& Graham, N.J (2016). Physical science learning in high poverty elementary schools in an urban district in grades 3 to 5 is influenced by STEAM lessons. According to the findings, students who got just nine hours of STEAM training boosted their science achievement. Ahmad et al., (2021) echoed similar finding that STEAM has a favorable impact on learning outcomes, with students' average grades increasing significantly before and after participating in STEAM classes.

Park, Kim, and Lee (2018) In STEAM-based faux engineering programs, 3D modelling and printing have been utilized to improve student learning results and attitudes about technology. Students achieve high scores in the engineering courses and feel confident with the courses (Kim& Bolgel, 2017; Quigly & Herro, 2017; Thunberg, Salmi & Bugner, 2018, Yakman & Lee, 2012). Previous studies have found that STEAM approach to have favorable effects on academic attainment and motivation. Students feel motivated in the learning process because they learn by doing experiments and projects. Knowing the process and applying the learning concepts in the activities, students will understand what they learn and they can get a good achievement in their examination.

Positive impact in cognitive development

Connecting STEAM and literacy can help youngsters develop their cognitive skills, enhance their literacy and numeracy skills, and reflect on their work in meaningful ways. Several studies and technological products relating to the function of art in STEM have been acknowledged, according to Swaminathan & Schellenberg (2015). According to Swaminathan's research, learning arts can aid students in improving cognitive skills such as spatial reasoning, abstract thinking, divergent thinking, self-creativity, openness to experience, and curiosity. In technology items, an electronic display screen that uses a combination of red, blue, and green dots to produce all of the different hues is utilized. As a result, by incorporating STEAM approach into formal education, pupils will experience a positive impact on cognitive development beginning at a young age.

According to Barbre (2017), incorporating STEAM courses into VR instruction improves students' abstract notions, learning outcomes, and practical competence. This is because when students work in group discussions, they do the experiment and use the concepts that they had to learn in solving problem activity. From the activity, they will apply the knowledge in a real situation (Kang, 2019). Both cognitive and affective learning will be influenced by STEAM education. The experience in elementary school showed that the effect could last a long time. Students will get the experiences when they are doing the activities by themselves. They will

remember the facts and they also learn about how to communicate with others in the class. Besides cognitive development, through, student-centered learning, STEAM education can also help students developing their communication and cooperation abilities. These abilities are required in both elementary and secondary school (Colegrove, 2017). STEAM activities will help students communicate and collaborate by delivering a meaningful learning experience by tackling a problem creatively or applying it to a real-world setting (Spyropoulou, 2020). People can acquire self-confidence and self-esteem through STEAM education.

Improve students' creativity and ability in problem-solving

STEAM education encourages students to be creative and efficient in problem-solving. They are trained to dominate 21st-century skills such as critical thinking to find out solutions to problems, creativity, collaborating with others, and communication to convey ideas. All these skills are important in the world of work. Herro, Jagques & Quigly (2018) STEAM aims to mix art with science, technology, engineering, and mathematics in order to improve students' problem-solving skills, as well as to demonstrate their creativity and ensure that they can develop artistic objects from a holistic and positive perspective.

Yakman (2008) broadens the scope of STEAM by incorporating arts into STEM, arguing that aesthetics and arts should not be overlooked in new approaches. When pupils are requested to draw something, for example, they must look more attentively at the objects and scrutinize them more thoroughly in order to notice the lines and shapes of what they are dissipating. As a result, they learn to notice even minor variations. While learning spatial thinking, students develop the ability to see a three-dimensional space by looking at a two-dimensional drawing. It is a skill that engineers, architects, and scientists must learn, and it also helps pupils understand difficult subjects.

STEAM learning approach can improve students' creative thinking skills. Students will develop their creative thinking skills when they involve in project-based activities (Ahmad et al., 2021). Project-based -learning such as design game, build model or product encourage students' creative ability. According to Liao (2016), the STEAM education approach supports experiential learning, creativity, problem-solving skills, and argue that STEAM is interrelated, students are encouraged to take risks, think critically, and find creative solutions to the problem. Learning approaches in STEAM education such as experiencing learning can train students to think creatively in solving problems (Kang, 2019)

Increasing students' interest in science

STEAM activities such as project-based learning, designing, gaming, and so on can attract students toward science. Those who took part in STEAM lessons, according to Hong (2018), had a stronger "science preference" than students who did not. They demonstrate higher degrees of ability to lead, cognitive strategy, learning motivation, and problem-solving motivation. Students had a lot of fun learning during Zoi Karageorgian's (2019) mobile programming and using a smartphone as a QR reader for 360-degree capture and editing exercises. It was a driving force for me to tutor others, conduct substantial research, and be very active. The students had a great time in class and came up with a lot of great ideas. Kajima (2021) stated that there was an improvement in youths' interest in engineering when they participated in the STEAM workshop. STEAM design thinking workshop increased participants' confidence in engineering subsequently their interest in science

increased. Quiqley et.al (2017) reiterated that STEAM learning emerged as a response to the need to increase students' interest and skills in STEAM. Students actively do their hands-on activities and they enjoyed the activities. According to Jamil et al. (2018), STEAM courses can improve students' motivation, attitude, and specific course success, as well as help students think about and integrate the connection between knowledge and practical engineering. The students expressed an interest in student-centered design activities and discussion. Students' interest will increase when STEAM approach implements in education because it provides students with an authentic learning experience that includes tasks, with real-world contexts, ill-defined problems, complex or multistep questions, multiple ways to approach a problem, integrate across the discipline, and have failed and interactions built into assignment itself.

Improve teachers' pedagogy

Teachers will improve their teaching methods via using STEAM approach. Teachers will be able to conduct their teaching in a variety of ways using student-centered learning methodologies such as project-based learning, process-based learning, and experiential learning. Secondary school teachers' perspectives revealed inter, trans, and cross-disciplinary learning impacted by teacher cooperation, dialogue, and classroom organization that supports critical and creative thinking, according to Harris and Bruin (2018). STEAM solutions, according to Segarra et al. (2018), are a useful complement to traditional teaching and training. More creative teaching activities and interests, such as gaming, gardening, dance, or crafts, might be added to the curriculum.

Oner et.al (2016) study stated that teachers who used Project-based learning will make the lesson more creative and active. Students were happy and interested when they were doing their project. The results showed that students were motivated in the lesson. Adding the arts in STEM also provides more options for the teachers to present STEM concepts to children, especially at the elementary and early childhood levels. Providing meaningful hands-on STEAM experiences for children positively impact their perceptions and dispositions towards STEAM (Spyropoulou et.al 2020). Teachers may use various methods in teaching such as story-telling, drama, or outdoor learning activities for children to learn.

STEAM education is a flexible teaching model. Teachers may use their creativity to teach students to reach positive outcomes. Promote learning experiences allow students to explore, question, research, discover, and exercise innovative building skills (Colker. et. al., 2014) From the literature, STEAM education can improve teachers' pedagogy and increase the education qualities. Teachers also have more opportunities to communicate with teachers and students during teaching activities. Moreover, a collaboration between interdisciplinary teachers helps relieve some of the pressure of developing lessons in isolation, thereby providing an atmosphere of creativity and innovation within the teachers' community (Doniger,2018).

Discussion

To make sure that STEAM education could be implemented in Malaysia, the stakeholders need to focus on the development of diverse educational material and programs that promote STEAM educations. Ministry of Education must be ready to develop a STEAM program such as utilizing the up-to-date product, an integration-based program in science and art, and a design-based program to promote future jobs. On the other hand, teachers and researchers can work together to develop a variety of high-quality teaching materials such as apps, modules, and teaching programs

that suit our curriculum. This is aligned with Ministry of Education Malaysia needs for 60% of science stream students in 2025.

Teachers' understanding of STEAM rose dramatically, and they developed more favorable attitudes about STEM, according to research (Coligrove,2017). Enhancing teachers' self-efficacy and confidence in teaching STEAM is vital to ensure STEAM could be implemented effectively in the classroom. Systematic training must be provided to teachers so that they understand the concepts of STEAM education and the know-how to apply STEAM into their lessons. Teachers need to mastered STEAM pedagogy; they have to prepare to teach interdisciplinary knowledge and skills, as well as effective outcomes, which are expected before STEAM education implement in the Malaysian education system. These findings are in line with Kajima's finding (2010) that teachers' knowledge in pedagogical will affect the quality of learning.

More studies are required to encourage the integration of STEAM into the curriculum in our countries (Hau,2020). Teachers' STEAM teaching capacity could be strengthened by professional development with elements of collaborative or classroom implementation. Further research on effective STEAM professional development program design principles is necessary besides STEAM implementation in the classroom.

Therefore, the Ministry of Education needs to prepare the curriculum, professional development, and learning materials before STEAM can be implemented completely in Malaysia.

Conclusion

Early exposure to STEAM brings many benefits to students. Integrated and exciting learning experiences improve students' interest in learning. Malaysian education needs STEAM learning model to interact with students' interest in STEM education. Arts is a new element that can be applied in Malaysia to enhance STEM education. Integrating multi-discipline in teaching will produce multi abilities students. Students become more creative, able to solve problems, improve their communication skills and more collaborative. These abilities are essential for future workforce.

Students' interest in science will increase when STEAM is implemented in learning activities. Increasing the interest in STEM will enable Malaysia to achieve the Ministry of Education's target to have 60% science stream students in 2025. STEAM will become a new approach in teaching science as it encourages students' learning by doing and providing opportunities to learn in real life situations.

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