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Review Article

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Creative methods in STEM for secondary school students: Systematic literature review

Nurin Nuha binti Zakeri [1], Riyan Hidayat [1]*, Nur Atikah binti Mohd Sabri [1], Nurul Fashihah binti Yaakub [1], Kayshalini S Balachandran [1], Nurul Izzah binti Azizan [1]

[1]Department of Mathematics, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, Perak, MALAYSIA
***Corresponding Author:** riyanhidayat@fsmt.upsi.edu.my

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ABSTRACT

Science, technology, engineering, and mathematics (STEM) are recognized as critical subjects that underlie innovation and national prosperity. Through inquiry-based learning, STEM subjects contribute to the development and application of these abilities. Therefore, the main purpose of this research is to explore type of creative methods in STEM for secondary school students. Articles from 2017 till 2021 screened and analyzed using systematic literature review (SLR) and PRISMA protocol. Three online search engines used are Springer, Scopus, and Science Direct. The thematic analysis method is used to analyze the data. A total of 22 articles were chosen for the systematic analysis after being screened using the eligibility requirements. Result showed that the creative teaching methods involving STEM used in the current study were a problem and project-based learning, mathematical modelling, inquiry-based learning, design-based learning, tool-based pedagogy, student-centered learning, 5E instructional model, professional development, board games and role-play, STEM 7E-learning cycle and boundary-crossing. From twenty-two articles chosen, 77% used qualitative approach in existing literature of creative thinking. Our findings indicated that the distribution of STEM education in different countries such as Australia, Germany, Indonesia, Malaysia, Spain, and the US. At the end, STEM in mathematics education gives a positive out-turn overall.

Keywords: mathematics education, PRISMA protocol, secondary school, SLR, STEM

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INTRODUCTION

Science, technology, engineering, and mathematics (STEM) is a form of education in which disciplines are taught together. STEM education plays an important role as it has a distinct effect on students' learning objectives. STEM identity has been shown to have a powerful role in an individual's success in educational environments, as well as on their career goals and trajectories (Singer et al., 2020) among Gen-Z (Qudratuddarsi et al., 2022). STEM education focuses on closing the learning gap by putting educators at the forefront of the experience, transforming them from passive listeners to active learners. Along with foundational disciplines, STEM approach to education develops creativity and divergent thinking as it encourages young people to develop new technology and concepts. Students benefit from inquiry-based coursework because they focus on practice and innovation. Effectiveness of involving STEM in learning studied and how far it benefits the high school students. Integrated STEM is typically invoked when discussing education policy, curricula, and economic competitiveness, but the acronym has also become a cornerstone of education for so-called twenty-first-century skills (Hallström & Schönborn, 2019).

Mathematics involves various subtopics which involves problem solving questions where both student and educator have to think critically such as mathematical reasoning, probability, and geometry. For example, geometry requires visualizing abilities, but many students cannot visualize three-dimensional objects. The lack of understanding in learning mathematics often causes discouragement among students, which invariably lead to poor performance. Creative teaching methods involving STEM by teachers' preparation and capabilities in delivering STEM subjects throughout the instructional process are important to boost students' interest in learning. It is believed that teachers who understand the learning and facilitation of integrated STEM disciplines provide opportunities for pupils to recognize and pursue STEM fields in schools, whether formally or informally. To execute education utilizing integrated STEM, teachers' pedagogical skills in developing 21st century skilled pupils are a must in line with the technological development of the country. To combat the drop of students' enrolment in STEM, teachers must use their experience to equip themselves with appropriate instructional approaches based on the level of student performance.

Based on the findings, there are few avails from application of STEM in mathematical teaching and one of them is promoting active learning. The principle of 'active learning' is grounded in the constructivist tradition and is broadly understood as any approach to

instruction that encourages active rather than passive engagement (Wilson, 2020). Moreover, reference shown that 3-D printers are one of the creative teaching methods involving STEM that have the ability to benefit both the student and the instructor as a teaching tool. Teacher professional development (PD) and technical assistance are required for proper use of 3-D printing technology in the classroom. Using 3-D printers prepares students for a future in which comparable technologies will become more prevalent, emphasizing the importance of 3-D printing in STEM education, and implying higher use in the near future (Barroso et al., 2017). The relationship between STEM and mathematics were determined. Teachers' readiness and competencies in delivering STEM subjects through the teaching process play a role to engage students' interest. The exploration and implementation of effective strategies in teaching enhance student engagement and competence not only in STEM fields but also in 21st century skills such as creative problem solving, collaboration and digital and information literacies (Rahman et al., 2021).

Extant literature proves that there are several literatures in teaching mathematics involving STEM (Bergsten & Frejd, 2019; Beswick & Fraser, 2019; Leung, 2018). However, there are limited SLR on teaching mathematics involving STEM. Some literature focused on elementary schools while this research only takes count on the secondary school students. The purpose of this study was to analyze how creative method involving STEM assist in teaching mathematics for secondary school students. Rejected articles involves the one with older published dates which were not up to date with current scenario. Whereas there were also literatures focused on the career of the students and how STEM education helps in the working life which contradicts this research topic involving teaching for students only. Mathematical modeling, inquiry-based learning, and tool-based pedagogy could go hand in hand to provide a possible STEM pedagogy framework for mathematics and science (Leung, 2018). The innovation that differs this SLR from previous studies is that we have specified to only teaching strategies involving STEM in Mathematics. At the end of this SLR, a list of creative teaching methods in mathematics for secondary school students will be determined together with the positive effect of involving STEM could be investigated.

Research Questions

1. What are the creative teaching methods involving STEM that can be applied in mathematics education?
2. What is the design used in the existing literature of creative teaching methods involving STEM?
3. How is STEM education distributed in different countries?
4. What kind of interdisciplinary context in STEM employed?

LITERATURE REVIEW

STEM Approach in Mathematics

Mathematics is acknowledged as the fundamental foundation of all other disciplines and many students consider it a challenging subject (Diego-Mantecon et al., 2021). In conjunction with that, a creative educator must build and implement innovative teaching strategies to create a more motivating, engaging, and instructive classroom environment for both teachers and students. Besides, creativity in education is becoming a more highly focused and prominent aspect of academic discourse (Harris & de Bruin, 2017). Integrating STEM education is one of the creative educational approaches. Utilizing STEM education to teach mathematics is the most effective method because it encourages students to develop creative and higher-order thinking abilities, which are essential for understanding certain topics. Therefore, to improve STEM education and begin problem-solving through mathematics, the objectives of STEM education need to be revised and updated.

Besides, STEM integration in education is gaining importance and an increasing number of teachers have been focusing on the modeling of integrated STEM education (Beswick & Fraser, 2019). This is because STEM education involves both the theoretical and practical elements that equip students with tools of these subjects. STEM education provides the ideal combination of course modules and some required lab assessments and group projects to enhance students' knowledge. Wahono et al. (2019) stated that STEM education combines many fields of study to emphasize real-life problem-solving, which differs from traditional teaching methods. STEM education focuses on an integrated approach that highlights the relationship between STEM. The traditional method, on the other hand, taught the four components of STEM separately. In conclusion, the STEM approach in mathematics is great since it may create innovative thinking and individuals who can make better choices.

However, implementing STEM into teaching raises several challenges. One of the challenges is a lack of knowledge of the interdisciplinary aspect of STEM-based curricula, specifically how to effectively integrate STEM-related subject areas (Dong et al., 2020). Considering STEM education is a relatively new field, many teachers may only have a moderate knowledge of STEM ideas and insufficient knowledge of how STEM education works (Maass et al., 2019). The teachers or educators are unprepared and lack the basic pedagogical content knowledge to implement STEM education. Consequently, teachers may have difficulty planning and teaching STEM if they do not comprehend the fundamental theoretical foundations. Furthermore, poor knowledge of the theoretical foundation puts teachers at risk of choosing enjoyment over guiding learners through conceptual growth in science when preparing courses (Chu et al., 2018). These kinds of challenges must surely be confronted in order to properly implement STEM educations in high schools.

The teachers should participate in STEM programs that are designed to train and prepare subject teachers to incorporate STEM education in schools. This program is important to help teachers understand the disciplinary core ideas and cross-cutting concepts in STEM education to keep pace with the 21st century methods (Dong et al., 2020). Training is concerned with the development of certain skills to a targeted standard through learning and practice. The educators or teachers will acquire deep knowledge about all STEM disciplines and learn how to reassess their classroom environment properly through training programs. Besides, they also will develop analytical skills and mathematical skills in STEM, research, and project-based learning pedagogies to confidently integrate them in the classroom and actively promote diversity in STEM education for all students (Li & Schoenfeld, 2019). In summary, each teacher must have a deep understanding of STEM education and skillsets to implement teaching methods that involve STEM so that teaching delivery is excellent, and students easily follow the learning process.

Educators need to create and employ more creative teaching strategies involving a range of individual and group activities to

Table 1. The inclusion and exclusion

Criteria	Inclusion	Exclusion
Publication year	Published in 2017 until 2021	Published before 2016
Language	English language	Other than English language
Types of references	Article and journal review	Not an empirical study such as book, thesis, and proceeding
Scope of research	Education	Other than education scope

successfully implement STEM education (Dong et al., 2020). The teachers need to do some research and learn the most suitable approach of teaching in order to deliver an effective lesson. Creativity plays a major role in developing critical thinking skills, planning, and boosting students' interest in learning mathematics. Besides, the more challenging the problem, the more creativity is needed to solve the problems (Conradty & Bogner, 2020). As we know, STEM education deals with various problems such as mathematical modelling, which is the process of mathematizing, analysing, verifying, revising, and generalizing real-world situations or complex systems by using mathematical methods in the most general sense (Maass et al., 2019). Therefore, to implement STEM education, it requires creative teachers who possess all of the essential knowledge and skills and the ability to solve mathematical problems.

In addition, creative techniques of teaching involving STEM also contribute to improve students' motivation towards the subject of mathematics. To keep students motivated and engaged in the classroom, teachers must provide a variety of STEM-related activities. Incorporating concepts of active learning design through the creation of semester-long projects emphasizing critical and creative thinking is one of the creative STEM teaching techniques (Chen & Lin, 2019). These activities will create healthy competition among students and also encourage them to gain and comprehend the knowledge to obtain a great score on their examination. However, students will only tend to remember the information in textbooks rather than understand the issues due to time limitations and being unable to grasp STEM concepts if creativity is not included in teaching mathematics involving STEM. (Wahono et al., 2020). In conclusion, new teaching approaches that involve STEM can better prepare individuals for twenty-first-century skills and assist students in solving mathematical problems related to STEM education.

METHODOLOGY

Systematic Literature Review

In this research, an SLR was performed to ensure that the researchers can find the data systematically and qualified to be used in finding the creative teaching methods in mathematics for secondary school. In SLR, PRISMA protocol is used to identify, select, and critically appraise research to answer a formulated question (Dewey & Drahota, 2016). The researchers can also evaluate the validity and quality of existing work against a criterion to reveal weaknesses, inconsistencies, and contradictions (Paré et al., 2015). We can test a specific hypothesis and develop new theories by summarizing, analysing, and synthesizing a group of related literature. Hence, the researchers conducted a SLR to get the splendid article to answer the question for the research. To date, there are several applications of SLR in mathematics education (Hamzah, & Hidayat, 2022; Hidayat et al., 2022; Khaizaar & Hidayat, 2022; Man et al., 2022; Mohamed et al., 2022).

Searching Strategy

Searching strategy is very important in order to get a database needed based on the research question. The online search engine or database is used to find relevant material for creative teaching methods in STEM for secondary school students. Thus, three online search engines being used are, e.g., Springer, Scopus, and Science Direct. These three search engines are well established and well known in the field of finding references, including articles. The researchers find the article using random keywords in the online database to get various articles and journals which reliable or connected to the best creative method.

Selection Criteria

In selection criteria, it shows the earlier stage the researchers did before getting the materials needed. Firstly, the researchers managed to select the materials strictly using three different keywords to find the admirable materials, which are, as follows:

1. Studies which focused on creative teaching methods.
2. Studies, which focused mainly on STEM.
3. Studies which focused on secondary school's students.

Next, the researcher will determine the inclusion and exclusion criteria to make sure the data found are valid and can be used as good references for the research. **Table 1** depicts the inclusion and exclusion.

Based on **Table 1**, the inclusion and exclusion criteria have been determined. Firstly, the article will be filtered by setting the article to all open access and the year of the publication changed from the past five years only, which is from 2017 until 2021. The language also will be strict only in English. It will be easier for the researchers to understand and make filtrations. Next, the types of references that will be used are only articles and journals which more to education. So, the researcher will get the best results for the research.

Study Selection

To get the relevant materials that match the objective of the research, the researchers use preferred reporting items for systematic reviews and meta-analyses (PRISMA). It will show us how to run the systematic review, eligibility and exclusion criteria, steps of the review process (identification, screening, and eligibility), and data abstraction and analysis (Rahman et al., 2021). **Figure 1** indicates PRISMA.

By referring to the figure above, we know that the PRISMA protocol has four stages of finding materials which are identification, screening, eligibility and included. In the identification stage, the researchers have stated the articles and journals from three different online search engines, which is 24 articles in Science Direct, 64 articles in Scopus, and 284 articles in Springer. Then, the researchers removed the article, which is duplicate. The total of the removed article is 302 out of 372 articles. In the screening stage, there are 224 articles were removed after the screening process and there are 78 articles left. After that, in the eligibility stage, the researchers will go through the articles and filter them by looking at the main objectives and sample size of the article. There are 30 out of 78 articles assessed for eligibility. Then, the

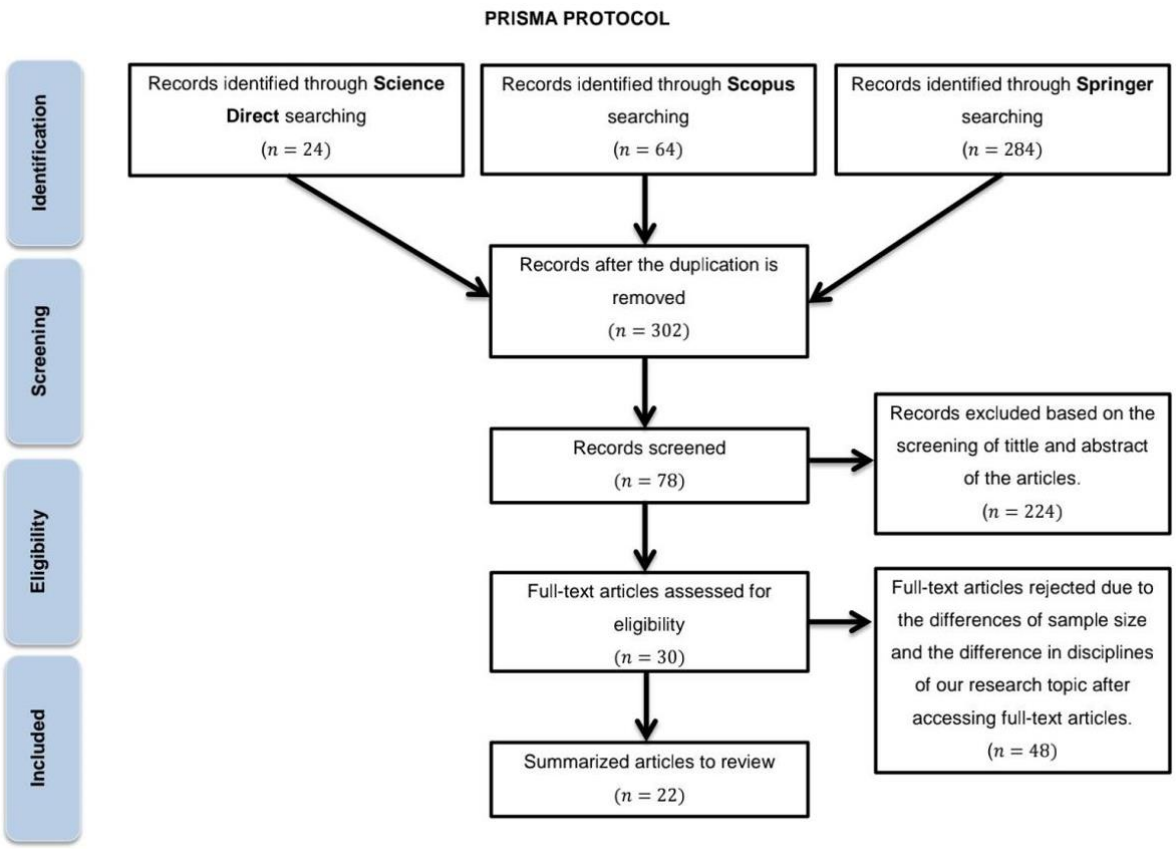

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) (Source: Moher et al., 2015)

researchers went through the full text of the article and found that there were only 22 articles that will be reviewed in this research.

Data Analysis

To get the real data to be reviewed, the thematic analysis method is used to analyse the data. This method is a suitable method to sort the qualitative data, which can really help us in the research. The themes were defined and grouped by the two independent authors by grouping the findings based on their similarity or relevance to ensure the reliability of the current work. Not only that, the article also will be analysed based on the research question to get the theme of the research. The research questions, which are being referred to

1. what are the creative teaching methods involving STEM that can be applied in mathematics education?
2. how does STEM education being impacted in future?
3. what is the design used in the existing literature of creative teaching methods involving STEM? and
4. how is STEM education distributed in a different country? From this, the review article will be selected and analysed easily by the researchers.

FINDINGS

A total of 22 articles were chosen for the systematic analysis after being screened using the eligibility requirements. This study used four research questions to guide its review of the selected articles. **Table 2** summarizes and compares the papers that were chosen, which included

Table 2. The content analysis on reviewed article

Author/year	Research question 1	Research question 2	Research question 3	Research question 4
Attard et al. (2021)	Inquiry-based learning	Developing in 21st century skills	Qualitative approach	(Germany) Develop students' skills
Beswick and Fraser (2019)	Problem or project-based learning	Developing in 21st century skills	Qualitative approach	(Australia) Guidance for teachers
Chen and Lin (2019)	Project-based learning	Provide authentic real-world situation learning and improved practical skills	Qualitative approach	(China) Future jobs
Chu et al. (2019)	5E instructional model	Applied in real world problem	Qualitative approach	(Australia and Korea) Develop students' skills
Contradty and Bogner (2020)	Professional development (PD)	Provide authentic real-world situation learning	Qualitative approach	(the US) Future jobs
Diego-Mantecon et al. (2021)	Project-based learning	Provide authentic real-world situation learning	Qualitative approach	(Spain and Aussie) Guidance for teachers
Dong et al. (2020)	Mathematical modelling approach	Provide authentic real-world situation learning	Quantitative approach	(Australia) Improve economic of nation

Table 2 (Continued). The content analysis on reviewed article

Author/year	Research question 1	Research question 2	Research question 3	Research question 4
Harris and de-Bruin (2018)	Inquiry-based learning	Provide authentic real-world situation learning	Qualitative approach	(Australia) Improve economic of nation
Kaspersen and Ytterhaug (2020)	Not specific	Learn conceptualize knowledge for real world situation	Qualitative approach	(Norway) Guidance for teachers
Leung (2018)	Tool-based pedagogy	Developing in 21st century skills	Qualitative approach	(China) Develop students' skills
Li and Schoenfeld (2019)	Design-based learning	Provide authentic real-world situation learning	Quantitative approach	(the US) Future jobs
Lin et al. (2021)	Student-centered learning	Accomplish real world problem solving	Qualitative approach	(Spain) Guidance for teachers
Maass et al. (2019)	Mathematical modelling approach	Provide authentic real-world situation learning	Quantitative approach	(Europe) Improve economic of nation
Morrison et al. (2021)	Project-based learning	Provide authentic real-world situation learning	Qualitative approach	(the US) Guidance for teachers
Nasri et al. (2020)	Not specific	Provide authentic real-world situation learning	Qualitative approach	(Malaysia) Guidance for teachers
Parno et al. (2019)	STEM 7E learning cycle	Provide authentic real-world situation learning	Quantitative approach	(Indonesia) Future jobs
Robinson et al. (2021)	Board games and role-play	Provide authentic real-world situation learning	Qualitative approach	(Australia) Guidance for teachers
Sutaphan and Yuenyong (2019)	Problem-based, project-based, inquiry, design, and a real-world problem	Provide authentic real-world situation learning	Qualitative approach	(Thailand) Improve economic of nation
Vale et al. (2020)	Boundary crossing	Developing in 21st century skills	Qualitative approach	(Australia) Develop students' skills
Vossen et al. (2020)	Design-based learning	Provide authentic real-world situation learning	Qualitative approach	(Netherlands) Future jobs
Wahono et al. (2020)	Project-based learning, problem-based learning or the 6E learning model in enacting STEM education	Facing the real-life problem	Quantitative approach	(Taiwan) Develop students' skills
Wang et al. (2020)	Mathematical modelling approach	Provide authentic real-world situation learning	Qualitative approach	(the US) Guidance for teachers

the inclusion criterion of a systematic review of the literature, creative methods involving STEM that can be applied in teaching mathematics, the impact of STEM, research design used for investigating the involvement of STEM in mathematics and geographical distribution of the authors. Each of these research questions is further discussed in the subsections that follow.

The Creative Teaching Methods Involving STEM

The first research question was concerned with many sorts of creative teaching methods involving STEM that can be applied in mathematics education. The creative teaching methods involving STEM used in the current study were a problem and project-based learning, mathematical modelling, inquiry-based learning, design-based learning, tool-based pedagogy, student-centered learning, 5E instructional model, PD, board games and role-play, STEM 7E-learning cycle and boundary-crossing. The data gathering methods employed to measure creative teaching methods involving STEM were examined in this review research (**Table 3**).

The majority of teaching methods that involve STEM were problem and project-based learning (n=6), followed by mathematical modelling (n=3), inquiry-based learning (n=2), design-based learning (n=2), tool-based pedagogy (n=1), student-centered learning (n=1), 5E instructional model (n=1), PD (n=1), board games and role-play (n=1), STEM 7E-learning cycle (n=1), and boundary-crossing (n=1).

Table 3. Creative teaching methods involving STEM

Creative teaching methods	Percentage (%)
Problem- and project-based learning	30
Mathematical modelling	15
Design-based learning	10
Inquiry-based learning	10
Tool-based pedagogy	5
Student centered learning	5
5E instructional model	5
Professional development	5
Board games and role play	5
STEM 7E learning cycle	5
Boundary crossing	5

Problem and project-based learning (Beswick & Fraser, 2019; Chen & Lin, 2019; Diego-Mantecon et al., 2021; Morrison et al., 2021; Sutaphan & Yuenyong, 2019; Wahono et al., 2020) has been extensively utilized as a creative teaching technique to incorporate STEM education in mathematics. Wahono et al. (2020), for example, teachers can incorporate STEM education with a problem and project-based learning method because it would help teachers achieve the class objectives while also benefiting students in acquiring new knowledge and engaging in thinking activities to create creative solutions.

Lastly, based on other findings, they concluded that mathematical modelling is also one of the most effective approaches in teaching

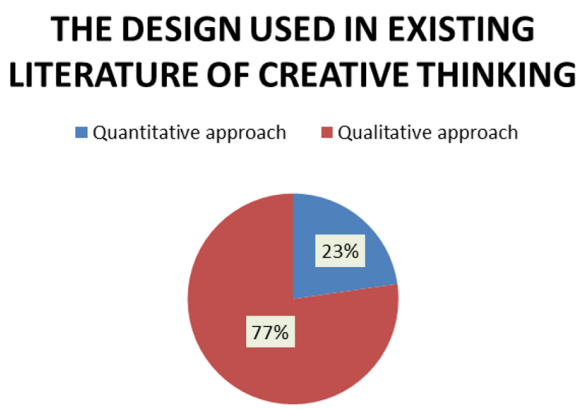

Figure 2. The design used in existing literature of creative teaching methods involving STEM (Source: Authors)

mathematics involving STEM. It will benefit students in learning how to solve problems based on real-world situations by using their ideas and information from STEM because different perspectives on modelling processes imply different perspectives on modelling competencies and abilities (Dong et al., 2020; Maass et al., 2019; Wang et al., 2020).

The Design Used in Creative Teaching Methods Involving STEM

The third research question emphasizes the design used in existing literature of creative thinking. The framework of research methods and techniques chosen by a researcher is known as research design. There are several types of research and its sub-type which explain by the design of a research topic. The study's design can be divided into two categories: quantitative and qualitative. Quantitative research can be related with numbers where give a better perspective in making a critical business decision while qualitative research is used for any cases to find links between acquired data and observations by using a mathematical computation. Therefore, both study's design is used in existing literature of creative thinking.

Figure 2 shows the percentage of design approach. From twenty-two articles chosen, seventeen articles (77%) used qualitative approach in existing literature of creative thinking. Obviously, qualitative approach has dominated the design used in existing literature of creative thinking where it is used most frequently (Attard et al., 2021; Beswick & Fraser, 2019; Chen & Lin, 2019; Chu et al., 2019; Contradty & Bogner, 2020; Diego-Mantecon et al., 2021; Harris & de Bruin, 2018; Kaspersen & Ytterhaug, 2020; Leung, 2018; Lin et al., 2021; Morrison et al., 2021; Nasri et al., 2020; Robinson et al., 2021; Sutaphan & Yuenyong, 2019; Vale et al., 2020; Vossen et al., 2020; Wang et al., 2020). Last but not least, only a few studies used quantitative approach where only five articles (23%) in existing literature of creative thinking.

Countries Distribution

The last research question highlighted the reasons STEM education spread around the world. The high rate of technological innovation is causing significant societal and economic change around the world, pushing economy away from manufacturing and toward information and knowledge industries (Dong et al., 2020; Maass et al., 2019). Many people are concerned about the impact of STEM education on innovation and progress. Agriculture, industrial, military, and consumer goods innovation and manufacturing are the nation's economic strength. Many countries' policies continue to be pushed in the direction of STEM education (Sutaphan & Yuenyong, 2019). 18% of the country were state that in the future STEM help in improve economic of nation. A sample of students' work from the experiment mathematics lesson is provided and reviewed in order to demonstrate students' problem-solving skills as well as their mathematical and scientific thinking. The experiment mathematics experiment lesson is then used to identify pedagogical elements that may describe a STEM boundary pedagogical approach (Leung, 2018; Wahono et. al., 2020). 23% of country include Australia, Korea, and Taiwan state that STEM help in develop students' soft skills in education.

Teachers built a STEM-PjBL framework for makers that promotes students to engage in hands-on work and exploration learning, enhances students' ability to respond to difficulties in a rapidly changing world, and may assist weak academic students obtain good jobs in the future (Chen & Lin, 2019). 23% of different country state that STEM help student to improve their soft skills to find job in the future. Some lecturers used tactics such as a reverse design activity to guarantee that students learn how to do research. Because various students appear to favor different approaches of creating, the findings of this study raise the question of whether all students should apply research activities in the same order during the design process. A design-oriented STEM module like this one is a good place to start showing students how research plays a role in design but differentiating between students' preferences could help to improve the learning process (Vossen et al., 2019). 36% from different country were suggested the best way for teacher to improve their skills in teaching about STEM.

DISCUSSION

Findings from this study may have implications for creative teaching methods and how does STEM studies affect students' future. The results demonstrate that the majority of articles in the study of STEM education used problem and project-based learning, as well as a mathematical modelling technique. The findings of the study are in line with Rahman et al. (2021) who stated that problem-based learning and project-based learning can enhance students' outcomes in STEM education. The creative teaching methods involving STEM that can be applied in mathematics education are limited and yet to be broaden by educators. Creative methods rarely only focus on learning mathematics but also educate students on soft skills and moral principles. For example, creative methods such as board games and role play which were discussed in the articles involves a group of people, where objective of the study can only be achieved with a productive collaboration among the students whereas on the other hand, methods such as project-based learning gives the best insight involving teaching with STEM studies. Various methods identified through this review where educators could choose to plan their teaching based on their convenience and students' or environment behavior. The pros of the study involving the first research question is that plenty of creative teaching methods involving STEM that can be applied in mathematics education discovered. But ways to run the methods are unclear and the time span to hold the method is not mentioned understandably. Moreover, other cons were that the respective mathematics topics where the methods could be applied were not mentioned in the study. Thus, the need of solid strategy from the teachers' side could help the learning process to be better as involving STEM in teaching mathematics are both fun and complex.

To assist teachers and STEM programs in developing STEM talent, suitable provisions must be made so that they can act as a facilitating catalyst in the growth of students. In order to implement STEM studies among secondary school students, suitable methods are important to attract the interest among students to further learn. The teacher plays an important role in this environment, and therefore, the person and environment work together to develop STEM talent in this model. STEM education includes student use of math and science concepts they have learned in an applied setting through the use of engineering design and technology. Instead of being taught in a vacuum, math and science are brought to life through their need to be used in order to solve a real problem. This is due to the fact that STEM education includes both theoretical and practical components that give students access to the necessary tools for these fields. The articles reviewed mostly helped to answer the research question of this study, but the accuracy level was quite low as information and studies were more to general review and did not focus to mathematics.

Our findings indicated that the distribution of STEM education in different countries such as Australia, Germany, Indonesia, Malaysia, Spain, and the US. STEM education has been present for more than two decades (Timms et al., 2018). The changes in technology innovation among different countries affect the creative teaching methods involving STEM in mathematics. The rapid development and functional effects of STEM education programs in western countries have attracted the interest of many researchers and policy-makers from other countries (Sheffield et al., 2018; Timms et al., 2018), including Asia. Eastern countries face similar problems, where there is a lack of interest from the younger generation in careers related to STEM. As for Malaysian population, more than one third of the kids were uninterested in science and technology. Training focuses on the acquisition of certain abilities to a desired level through study and practise. Through training programmes, the educators or teachers will gain comprehensive understanding of all STEM fields and learn how to appropriately examine their learning environment. We can say that STEM studies help in finding better future jobs, developing skills, generally improving economic of nation and majorly as the guidance for teachers to pass the knowledge to younger generation. The pros of the study were that various factors on distribution of STEM education were known, and the review answered the research questions.

It can be discussed that STEM education gives a major impact in the future of learners especially the sample size of this study which were secondary school students. STEM education usually comes with hands on work. For problem solving problems or project-based learning, soft skills and good communication are important in order to tackle the faced consequence. The beginners will eventually develop their skills if the exposure of STEM education is continuous. Most articles reviewed used qualitative approach. Project-based learning is a student-cantered approach to instruction that has been shown to enhance student problem-solving skills, motivation, and conceptual knowledge (Darling-Hammond, 2008; Thomas, 2000). When students apply critical thinking skills to work with information, the outcome can be more effective learning and use of information (Hughes & Lavery, 2004; Li et al., 2019). We found that the reviewed articles emphasized on the after effect of STEM education which makes the learning powerful and stronger. Our finding echoes prior research suggest that challenging activities, goals for students, helps in preparing them for the future obstacles. Findings shows that existing literature of creative teaching methods involving STEM uses both qualitative research and quantitative research. Concerning the research design of literature review, most of the references used the qualitative approach as their design approach.

CONCLUSION

Creative approaches in teaching are very important and all teachers should implement them in the classroom. STEM involvement while teaching is an innovative approach that all teachers should try. STEM education is widely applied in all countries such as Australia, China, Europe, Malaysia, Taiwan, Thailand, and the US. Therefore, a teacher must be experienced and have an in-depth understanding of STEM to use it as one of the creative methods in teaching mathematics (Li & Schoenfeld, 2019). Based on previous researchers, problem and project-based learning, mathematical modelling, inquiry-based learning, design-based learning, tool-based pedagogy, student-centered learning, 5E instructional model, PD, board games and role-play, STEM 7E-learning cycle and boundary-crossing are the best methods that have been widely used in incorporating STEM. In our systematic review of creative teaching methods involving STEM, the current development focused on the problem and project-based learning. This method was also regarded as the best way to implement STEM in teaching. Our findings indicated that most of the approaches employed to integrate STEM were the problem and project-based learning. Also, the current systematic review also revealed that most published papers employed the qualitative approach as the data collection method. Finally, STEM has a major influence on students, particularly in terms of providing realistic real-world situation learning and developing 21st century skills.

Limitations

Different sample groups were one of the limitations where there were articles involving primary school students and high school students. Moreover, the year constraints made the research up to date and articles with interesting topics had to be removed from the review.

Future Directions

The scarcity of knowledge on how to implement appropriate creative teaching techniques in STEM-based mathematics education highlights the need for possible solutions to improve existing solutions. The implementation of more creative teaching methods such as problem and project-based learning, mathematical modelling, inquiry-based learning, and design-based learning should be emphasized, especially when it comes to mathematics subjects. Additionally, it is good for Malaysian teachers to explore STEM and integrate it into teaching mathematics. This is because it will enhance students' creativity and thinking abilities by tackling more challenging issues and advancing the quality of the education system. Lastly, future research should also explore the most effective techniques for teaching mathematics by integrating STEM in order to be more in line with students' environments and experiences. This is important for the research because STEM integration is challenging for persons, especially those with little experience or understanding.

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