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Teaching Activities for Integrated STEM in Elementary Education: A Systematic Review

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Abstract

Internationally, curricula undergo periodic changes to align the education system with the latest global demands. Careers in Science, Technology, Engineering and Mathematics (STEM) education play a crucial role in ensuring the success of these changes in school and in cultivating a future workforce that contributes to Malaysia's economy. It is essential to provide equal opportunities and exposure to the latest trends in education. In the last 5 years, there have been several literature reviews has been increased emphasis on designing teaching activities for integrated STEM (iSTEM) learning in elementary education. They investigating various learning of disciplinary concepts infused in integrated STEM in STEM subject and non-STEM subject. In addition, a broad-reaching review on integrated STEM not reaching broad review in five years 2019-2024. This article reports findings from a Systematic Literature Review concerning teaching activities for integrated STEM in elementary education for children aged 7-12 in formal education contexts. To provide context, the article presents systematic literature review findings country of research in the 10 research articles that are included for analysis. Findings from this research suggest that there is still much work to be done to move from scenarios where teaching activities for integrated STEM is claimed but is not evident in activities. Therefore, we suggest educators and researchers to focus on teaching activities for integrated STEM in elementary education through project-based learning that provide opportunities for authentic integrated.

Keywords: STEM Education, Integrated STEM, Project-based Learning, Elementary Education

Introduction

Along with world development, the demand for qualified human resources is also increasing with needs future workforce that contributes to Malaysia's economy. Integrated STEM is a combination of STEM subject and non-STEM subjects in teaching activities required to solve complex disciplinary problems applying iSTEM to facilitate the assessment of student learning outcomes (Uddin et al., 2021). However, iSTEM has been discussed with various opinions to be implemented teaching and learning activities in Project-Based Learning (PBL) by (Afriana et al., 2016; Widiyanti et al., 2020; Winarni et al., 2022). According to (Keleman, 2021; and Mckay, 2024) iSTEM is achieved through the implementation of teaching activities in PBL can

improve students collaboration, communication, creativity in thinking skills and meaningful. Despite the fact that (Yulhendri et al., 2023) suggested the iSTEM can be to seen the combination of subjects can also improve students' critical thinking and collaboration through teaching activities in Project- Based Learning.

Keleman, (2021) explained that the implementation teaching activities based on iSTEM can help students achieve higher thinking skills in the learning process to transfer knowledge and skills through PBL. (Dare et al., 2021) definitions PBL as an educational strategy approach in which students conduct their lessons and tasks performed by engineers in real world and working in teams to do research and solve difficult and complex learning problems (Pou et al., 2022; Sahin, Alpaslan and Top, 2015). Additionally, (Bates et al., 2022) describes PBL as a teaching activity that can be implemented into iSTEM education in the classroom to engage students in exploring real-world problems. PBL can also improve students' higher-order thinking skills (Keleman, 2021; Mohamad Nurul Azmi et al. 2017; Zhong et al. 2022). Moreover, integrated STEM in elementary education can increase the quality of human resources in industrialization and globalization to fulfill 21st century competencies (Winarni et al., 2022). Furthermore, iSTEM has been widely implemented in educational activities through PBL in various other domains including language (Wahyuni et al., 2020), astronomy (Burrows et al., 2021), geography (Foski et al., 2017), programming (Chang & Chen, 2022), and architecture (Foski et al., 2017).

Incorporating teaching activities for integrated STEM into PBL in elementary schools requires high levels of cognitive challenge, including elaboration, abstraction, iterative thinking, transformation, problem reduction, and reasoning. These abilities are critical in the development of problem-solving abilities. Implementing teaching activities with iSTEM in PBL for elementary education can improve students understanding of the basic skills that they need to learn starting in primary school. Implementing teaching activities with iSTEM in PBL for elementary education can improve students understanding of the basic skills that they need to learn starting in primary school. Furthermore, based on past studies, Integrated STEM in project-based learning can also be seen as a management process that involves a series of complex efforts based on challenging questions, research activities, decision-making and the creation of realistic and good outcomes (Blumenfeld et al. 1991; Dasgupta et al. 2019; Lin et al. 2018; Sulaiman et al., 2018; Sulaiman et al., 2024; Diego-Mantecon et al., 2021). Although there is no extensive literature on iSTEM in project-based learning in primary education, there is a lack of comprehensive studies that focus on citation analysis to reveal trends, patterns and research gaps in publications on this field in primary education. This paper conducts an SLR analysis of iSTEM in the project-based learning literature to look at previous publications, identify leading research areas, and uncover knowledge and networks. In addition to documenting iSTEM in teaching activities through project-based learning in primary education in 2019 and 2024, this study highlights key emerging research frontiers, on iSTEM teaching activities in project-based learning in the challenges STEM education.

Literature Review

Although other methods for discussing integrated STEM are present in the literature, for example, via teaching frameworks (Siew and Ambo, 2020) or in terms of integration STEM content, pedagogy, or context (Cheng and So, 2020), the dominant teaching activities used in the literature is one that frames iSTEM solely in terms of interdisciplinary. For example,

Dugger, (2010) categorized iSTEM into four categories: (a) four separate disciplines; (b) two of the four disciplines are emphasized, (c) one discipline is integrated into the other three, and (d) all four disciplines have equal emphasis and are approached in an interdisciplinary way. In a similar vein, (Uddin et al., 2021) investigates the contribution of individual disciplines in the successful projects such as disciplines Engineering, Biological Sciences and Technology appear as the principal disciplines in interdisciplinary research having a STEM focus. By contrast, non-STEM interdisciplinary research is led by disciplines-Studies in Human Societies, Language, Communication and Culture, and History and Archaeology. STEM is primarily Science, or Science and Mathematics, incorporating the other three or two disciplines, respectively, through the full integration of the four disciplines.

The teaching activities based on iSTEM in Project-Based Learning is very closely related to the project itself based on outdoor learning activities, project-based learning activities outside the room was in the form of training, guidance, and small group discussion (Sukamti et al., 2019). Teaching activities for Integrated STEM in Project-based learning requires interdisciplinary collaborative learning, guidance from the teacher, and is more process-oriented for product or results. According to Hsu and Shiue, (2017) Integrated STEM is based on relationships among three presences - cognitive presence, social presence and teaching activities presence in inquiry the interdisciplinary project-based learning and students decide for themselves what the output and effect will be produced. From a holistic perspective, teaching activities for integrated STEM in project-based learning enables the creation of an integrated context composed of elements such as flexible environments, learning culture, intentional content, and professional educators for practical experience, knowledge and cooperation resulting from research in the project carry out (Bergmann and Sams, (2014). In this sense, the relationship between teaching and learning produces a new learning environment, which, ultimately, not only enhances overall educational capabilities, even addressing the 21st century demands of education and also puts in practice a STEM acculturation in elementary school (Imbaquingo and Cárdenas, 2023; Ketelhut et al., 2020; Yulhendri et al., 2023).

In the context of this study, there are countries that have conducted iSTEM studies over a five-year period though publication (Santaolalla et al., 2020; Wan Rashid et al., 2020; Hsu and Shiue, 2017; Budi Setiawan et al., 2020). In fact, there are nine countries: Thailand, UK, Switzerland, Malaysia, Czech, USA, Belgium, Kosovo and China involved in research teaching activities for iSTEM in project-based learning in elementary education. This study also addresses the gaps in teaching activities for iSTEM into project-based learning in elementary education by conducting a SLR analysis literature review that is globally in Scopus and WOS databased. By examining 350 carefully selected documents, the study aims to provide a thorough view of the data supporting the efficacy current state, growth, and evolution of iSTEM in teaching activities in project-based learning in elementary education. The goal is to uncover emerging trends in STEM education, and identify the teaching activity a can implementation in iSTEM for STEM education challenges. This research aims to expand the existing knowledge base, answer research questions, and establish a strong foundation for future studies. This finding will be enriching research in STEM education though iSTEM in literature and also offering valuable insights for scholars, practitioners, and policymakers.
Therefore, the purpose of this SLR was to focusing on three main research questions outlined below:

1. Do most articles included in the dataset involve the integrated of STEM?
2. Which publication and countries are implementing teaching activities for iSTEM in Elementray education research?
3. What are the teaching activities used when applying iSTEM in Elementray education research?

This study provides a thorough understanding the varions of teaching activitis for iSTEM in project-based learning in elementary education research by using SLR method in the field. These researches are guiding the approaches teaching activities though learning of effective iSTEM in project-based learning for current education challenges. The research analysis aims to clarify the teaching activities for iSTEM in project-based learning in elementary education, offering a detailed overview of its past and present state in five years (2019-2024) while laying the groundwork for future advancements. Ultimately, this research seeks to enhance the effectiveness and innovation of educational systems through teaching activities base on iSTEM in project-based learning in elementary education.

Methods

This study used data from the Scopus and WOS database to reliable source of peer-reviewed literature. Both databases are known for its stringent quality control and wide geographical coverage, making it ideal for SLR analysis. The SLR analysis in both databases was chosen because it provides a broad overview of the research, identifying trends, and influential emerging areas in STEM education though iSTEM in elementary education. The data collected, publication institutional and country contributions to the teaching activities though iSTEM in elementary education research with providing into future STEM education.

This study using three procedure SLR (identification, screening for eligibility and inclusion) (see table 2). By using these three procedures, the author was able to search and synthesize the research in its entirety, resulting in a transparent and organized review.

Systematic Search Strategy

To examine the related publications, we followed the modified guidelines for systematic research reviews, Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram of the search strategy (Page et al., 2021). The terms ‘integration in STEM, ‘integrate STEM’, ‘PBL STEM’, ‘project STEM’, ‘elementary students’ & ‘STEM education’ were used in Scopus and WOS, along with subject filters to refine results (see Table 1).

Identification

Scopus and WOS are the primary sources for this SLR investigation. Scopus is a reference and theoretical database launched by Elsevier in 2004. WOS is a website that provides membership-based access to various databases and comprehensive reference information on a range of scholarly disciplines. Table 1 displays the keywords used to find publications relating to teaching activities though iSTEM in elementary education students.

Table 1
Search Keywords and Strings in Scopus and WOS Databases

Databases	Keywords used
Scopus	TITLE-ABS-KEY ((("integration* STEM" OR "integrated STEM" OR "STEM education") AND ("project based learning" OR "project STEM" OR "project STEM* elementary student"))) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "STEM Education") OR LIMIT-TO (EXACTKEYWORD , "Project-based Learning") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Education")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (SUBJAREA , "SOCI"))
Web of Science	(ALL=(("integration* STEM" OR "integrated STEM" OR "STEM education") AND ("project based learning" OR "project STEM" OR "project STEM* elementary student"))) AND (DT==("ARTICLE") AND LA==("ENGLISH") AND OAJ==("ALL OPEN ACCESS") AND PY==("2019" OR "2020" OR "2021" OR "2022" OR "2023" OR "2024") AND TASCA==("EDUCATION EDUCATIONAL RESEARCH") AND OAJ==("ALL OPEN ACCESS") AND LA==("ENGLISH") AND DT==("ARTICLE") AND PY==("2019" OR "2020" OR "2021" OR "2022" OR "2023" OR "2024"))

The study's scope was defined by search field, education level, and timeline, excluding irrelevant papers. Using PRISMA ensures a systematic, transparent, and replicable approach, providing a structured for searching, screening, and reporting data. This method helps eliminate bias through clear inclusion and exclusion criteria. This rigorous process resulted in 325 documents Scopus and 25 documents WOS (see Fig 1), all of which were included in the final database after thorough screening (see Table 1). The screening procedure was then restricted to items published between the years 2019 and 2024, considering (Kraus and Dasí-rodríguez, 2020) research field maturity concept. Because the amount of published research was sufficient to conduct a representative review, this timeline 2019 until 2024 was taken into consideration.

Screening all Document Founds

The next step is screening. During this step, the papers were either included or omitted from the research relying on a set of criteria (see in Table 2). Here, the first step includes eliminating journals (systematic literature reviews), novels, book and chapters as well as conference proceedings from being considered. The screening procedure was then restricted to items published between the years 2019 and 2024, considering (Kraus and Dasí-rodríguez, 2020) research field maturity concept. Because the amount of published research was sufficient to conduct a representative review, this timeline 2019 until 2024 was taken into consideration.

Table 2
Screening and Eligibility Criteria for Inclusion and Exclusion of Articles

Criterion	Screening for Eligibility	Exclusion
Literature review type	Journal (research articles)	Book, chapters, and systematic literature review articles in conference proceedings
Language	English	Not-English
Field	STEM education, integrated STEM, iSTEM in project-based learning	Not field education
Education level	Elementary education	Secondary and high education
Timeline	Between 2019 and 2024	Before 2019

Consequently, based on table above the author decided to exclusively examine empirical research papers written only in English. Provided that 350 articles did not match the inclusion requirements, they were excluded using this procedure.

Screening for Eligibility

The eligibility procedure is crucial in SLR analysis to ensure accurate and reliable results. Eligibility procedure has followed the screening method (see Table 2). The author personally examined the articles extracted to guarantee that all of the remaining articles met follow the requirements. This was achieved by reading the titles, abstracts, and complete contents of the papers. Therefore, 350 articles (325 documents Scopus and 25 documents WOS) were determined to be appropriate for additional screening and eligibility, which 3 duplicate articles, 120 excluded articles not follow requirements, 68 reports not retrieved and 149 articles excluded were eliminated after screening. Finally, there were ten papers that needed to be evaluated relying on the exclusion and inclusion criteria (see fig 1).

This part of the procedure resulted focus on teaching activities though iSTEM in project-based learning in elementary students and not are published as a non-STEM education for secondary and high level. Hence, the systematic literature review potentially comprised ten papers.

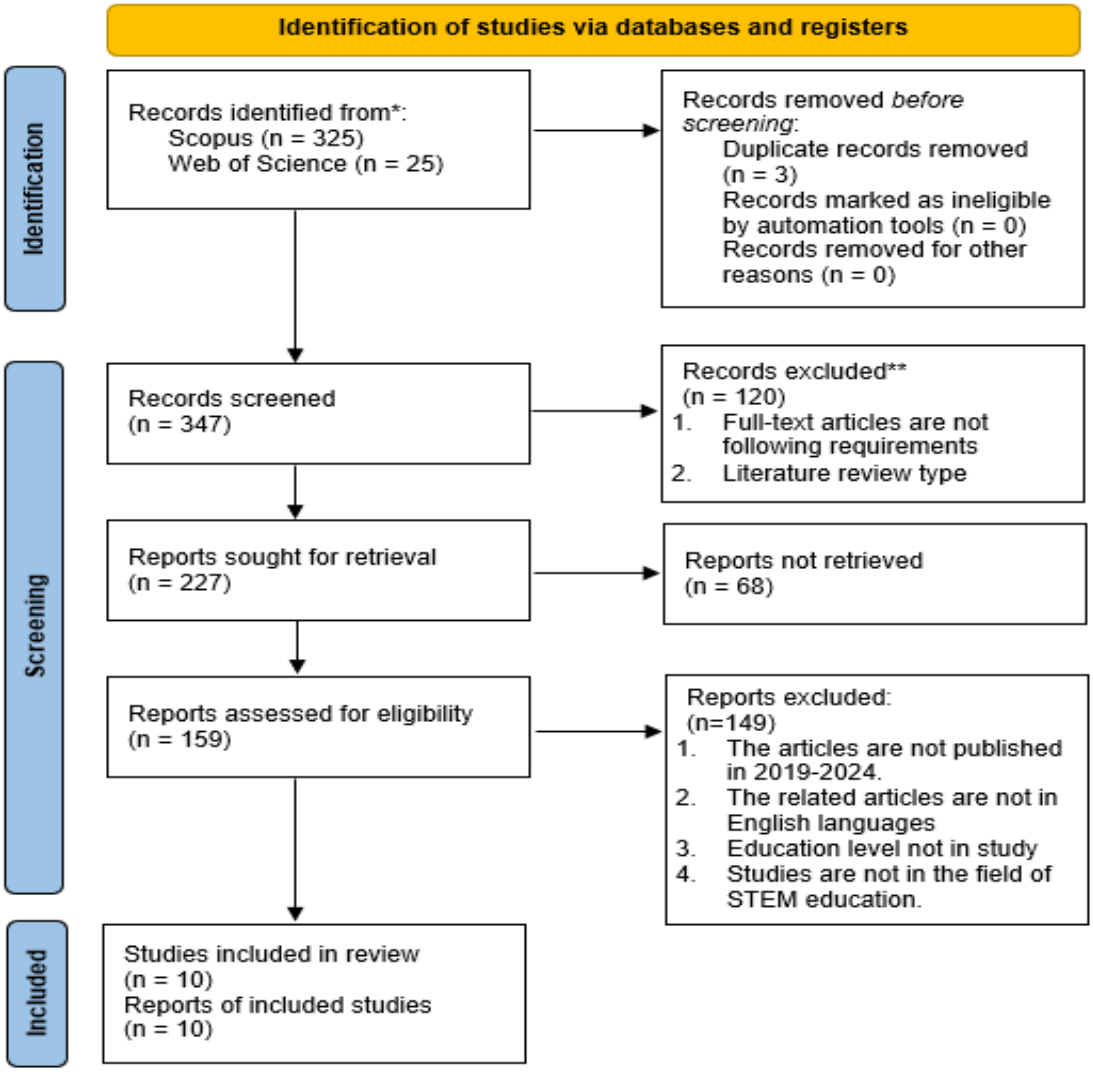

Figure 1. PRISMA 2020 flow diagram of the search strategy (Page et al., 2021)

Inclusion

The teaching activities for encouraging iSTEM in elementary education were the focus of the publications in this SLR. The Scopus and WOS databased were used to select ten articles for the Figure 1 given. These databases were selected for the quality and nature of their publications, particularly in the STEM education field though iSTEM for elementary students. The research's goals were all linked to teaching activities iSTEM in learning project activities for elementary students.

The search was limited the research to peer-reviewed journals articles between 2019 and 2024. The year 2019 was chosen as it was then that STEM education challenge in teaching activities iSTEM become a topic of focus education in time. To maximise replicability of our search strategy, we choose to only include peer-reviewed research published in journals. Following this process, the Scopus and WOS databases were used to select ten articles for the Figure 1. These databases were selected for the quality and nature of their publications, particularly in the iSTEM education field. The research's goals were all linked to teaching activities though iSTEM in project-based learning in elementary education. Figure 1 PRISMA following systematic literature review.

Data Analysis

Studies on teaching activities for iSTEM in Project-Based Learning in elementary education by Year of Publication

Publication trend are essential indicators for identifying a field's development. Between 2019 and 2024, not many articles were published on fostering teaching activities for iSTEM in elementary education. The articles were selected based on the research question. Figure 2 illustrates the distribution of the number of articles by year 2019 until 2024. The graph displays that the number of teaching activities for iSTEM in project-based learning in elementary education research articles increased to two articles in 2022 and flat in 2024. Despite an upward trend to two articles in 2022, interest in this field has been building with the publication of two articles in 2023 and 2024.

The graph shows that the number of articles on iSTEM in project-based learning in elementary education research increase continues until there were significant changes publications in 2022 and 2024. Since 2019, there has been a trend of only one publication and a decline again in 2020 and 2021, Figure 2 are the number of publications published in the field of iSTEM in project-based learning in elementary education development. Figure 2 Distribution of the number of articles of teaching activities iSTEM in project-based learning in elementary education from 2019 to 2024 (see Fig. 2).

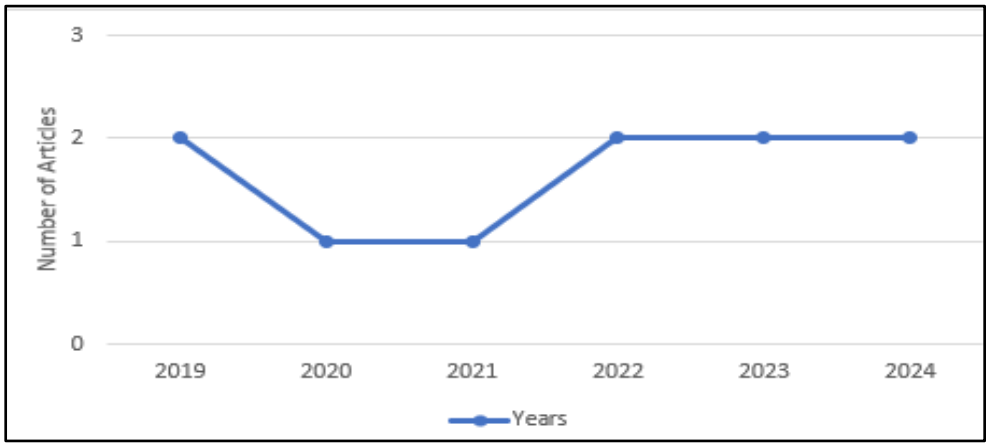

Figure 2. Distribution of the number of articles of iSTEM in project-based learning in elementary education from 2019 to 2024

The most articles in the databases involve the teaching activities though iSTEM in project-based learning in elementary education

Relying on the literature review, researchers discovered that seven of teaching activities were used in teaching activities though iSTEM in project-based learning in elementary education. The teaching activities used when applying activity iSTEM in project-based learning in elementary education such as, robotic activities (Prishtina, 2023; Hussin et al., 2019), student-centred learning activities (Struyf et al., 2019), inquiry-based learning activities (Mckay, 2024), project-based cooperative activities (Siew and Ambo, 2020), collaboration project activities (Bascopé and Reiss, 2021; Wood & Pranjol, 2024), creative thinking in project-based learning activities (Sutaphan and Yuenyong, 2023), and design -based learning activities (Major et al., 2022; Luo et al., 2022). The percentage of number the teaching

activities used though iSTEM in elementary education from 2019 to 2024 is illustrated in Figure 3.

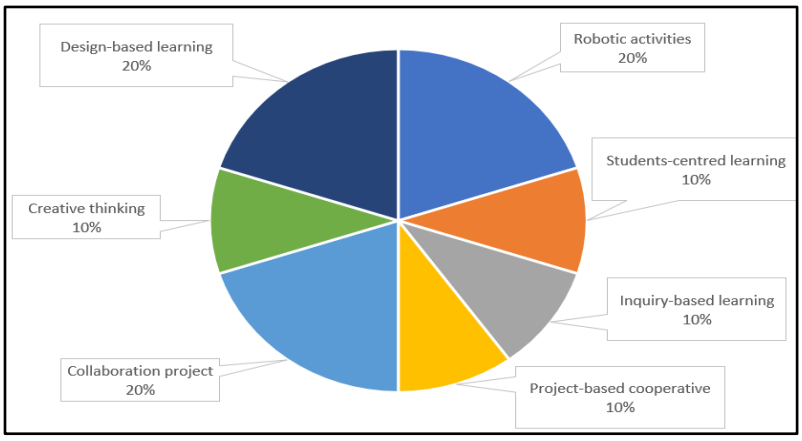

Figure 3. The percentage teaching activities used though iSTEM in elementary education

Based on the pie chart above represent about percentage the articles, this result offers a comprehensive analysis with regard to the most popular articles on iSTEM that have been used in project-based learning in elementary education are robotic activities, collaboration project and design -based learning are twenty percent articles. Meanwhile, student-centred learning, inquiry-based learning, project-based cooperative and creative thinking are ten percent article (see Fig.3) used teaching activities in iSTEM in project-based learning. Table 3 shows the summary of the teaching activities used in developing iSTEM in project-based learning in elementary education

Table 3
Summary of Teaching Activities in iSTEM in teaching activities Identified in Selected Studies (2019-2024)

No	Authors	Country/ A=ASEAN NA=Non-ASEAN	Teaching Activities for iSTEM in elementary education
1	Prishtina, (2023)	Kosovo (NA)	Robotic activities
2	Struyf et al., (2019)	Belgium (NA)	Student-centred learning activities
3	Mckay, (2024)	USA (NA)	Inquiry-based learning activities
4	Siew and Ambo, (2020)	Malaysia (A)	Project-based cooperative activities
5	Bascopé and Reiss, (2021)	Switzerland (NA)	Collaboration project activities
6	Wood and Pranjol, (2024)	UK (NA)	Collaboration project activities
7	Hussin et al., (2019)	Malaysia (A)	Robotic activities
8	Sutaphan and Yuenyong, (2023)	Thailand (A)	Creative thinking PBL activities
9	Major et al., (2022)	Czech, Europe (NA)	Design-based Learning activities
10	Luo et al., (2022)	China (A)	Design -based Learning activities

Based on the Table 3, there are nine countries: Thailand, UK, Switzerland, Malaysia, Czech, USA, Belgium, Kosovo and China involved in this research using teaching activities though iSTEM in project-based learning in elementary education.

Teaching Activities though iSTEM in project-based learning in elementary education

Robotic Activities

Two articles out of ten studies concentrate primarily on the robotic activities in iSTEM in project-based learning abilities. Robotic activities constitute the third percentage in developing iSTEM in project-based learning in elementary education. One study was performed in non-ASEAN countries (Prishtina,2023) and one study was conducted in ASEAN countries (Hussin et al., 2019). This systematic literature review explains various types of robotic activities used in iSTEM in project-based learning education, such as the implementation of the robotics competition project. This study investigates the effect of mBot robot activities in STEM subjects in project-based learning. The robotic activities determine their satisfaction and perceptions of the project carried out. Robotics building allows students to engage in 21st-century learning (Hussin et al., 2019). Robotics activities in project-based learning generally indicate effects on student's achievement (Prishtina, 2023; Hussin et al., 2019).

The results of the study by Abesadze and Nozadze, (2020) revealed that during the project's development, Generation X students learned robotics in programming and developed 21st-century skills, while primary school students' program while playing and learning simultaneously. Learning through robotic programming activities with game creation is an interesting and innovative method to use in practice (Abesadze and Nozadze, 2020).

Students-Centred Learning Activities

In a study, Struyf et al., (2019) discovered that students in a student-centred technology-enhanced STEM learning environment, reported higher levels of emotional engagement, than those in a teacher-centred learning environment.

A student-centred learning approach allows students to collaborate with peers and others frequently. At the same time, there is a pedagogical shift in favour of integrating the four disciplines of STEM at the school level into one class or a unit, based on the connections between the disciplines and real-world problems (Moore et al., 2014). As problems requiring an iSTEM activities are typically ill-structured with multiple solutions, iSTEM education requires a student-centred learning environment (Moore et al., 2014; Wood and Pranjol, 2024).

Inquiry-Based Learning Activities

Inquiry-based learning activities to learning in which students develop knowledge and skills in critical thinking and collaboration by exploring of real-world problems and development of public products (Baines et al., 2021; Mckay, 2024). Research has demonstrated that project-based learning can improve student outcomes, such as academic achievement, student engagement, and ownership of learning (Saavedra and Rapaport, 2024), including for students across racial and socio-economic groups (Deutscher et al., 2021; Duke et al., 2020; Krajcik et al., 2023).

Inquiry-based learning presents a strong alternative to this approach. However, the pressure to focus on basic skills can lead educators in schools labelled low-performing to prioritize teacher-cantered rote learning over instructional methods like project-based learning that promote higher-order thinking (Mohamad Nurul Azmi et al. 2017; Zhong et al. 2022)

Project-Based Cooperative Activities

Project-based cooperative in project is defined as "a teaching method in which students learn by actively engaging in real-world and personally meaningful projects" (Choque Soto et al., 2023). Holm, (2011) further referred to project-based cooperative as a "student-cantered instruction that occurs over an extended time period. This is when students select, plan, investigate, and produce a product, presentation, or performance that answers a real-world question or responds to an authentic challenge" (Holm, 2011). This definition suggests that project-based cooperative focuses on learning about authentic, interesting, and challenging real-life world problems.

Therefore, this study uses an integrated approach where STEM elements are combined in project-based learning and cooperative learning (CL), namely STEM project-based with a cooperative learning approach (STEM-PBCL). With this integrated approach, students are encouraged to think creatively and critically based on the combination of STEM disciplines in designing and making technical products in groups through the project-based learning process. Fifth-grade students, who are usually 10 to11 years old, are found to have high creativity (Smith and Carlsson, 1983) and are able to generate extraordinary ideas (Kim, 2011). Fifth-grade students in the project-based learning group are exposed exclusively to project-based learning with unstructured problem solving as given in the STEM-PBCL group. In solving unstructured problems, students are required to use their existing knowledge and skills and their reference data sources meaningfully (White and Frederiksen, 1998). STEM is an approach to interdisciplinary curriculum practices built around authentic problems, including some or all of the disciplines of Science, Technology, Engineering and Mathematics (Tytler et al., 2015). STEM, it is important that students experience iSTEM in project-based learning at the elementary education level.

Collaboration Project Activities

First, we will clarify what we mean by STEM activities, to provide comprehensive educational experiences in what we have called "STEM education for sustainability". After that, we will focus on the concept of resilience, applied to face socioecological challenges, understood as a process of transformation and adaptation at the individual and community level needed to face local and global social and ecological changes. Science, Technology, Engineering, and Mathematics Education for Sustainability (STEM4S) encourages children and youth to draw on their STEM competence and the process of science as a key basis for reasonable action in our world (Beardon, 2003).

STEM4S can promote raising reflective change-agents to impact their communities and society through a knowledge-based, action-oriented, participatory and integrative focus (Bascopé & Reiss, 2021). Furthermore, STEM4S can be linked to the active involvement of the local community. This calls for integrating science-based knowledge and its value for society with other forms of knowledge present in the locality in a way that transcends any discipline on its own to collectively address a common problem, transiting to a transdisciplinary focus. Furthermore, STEM4S can be linked to the active involvement of the local community. This calls for integrating science-based knowledge and its value for society with other forms of knowledge present in the locality in a way that transcends any discipline on its own to collectively address a common problem, transiting to a transdisciplinary focus (Wood & Pranjol, 2024).

Creative Thinking in PBL Activities

In Creative Thinking in Project-Based Learning, ideas can be developed by teachers or students, either individually or in teams through critical thinking (Oyewo et al., 2022). Furthermore, experiences outside the school environment allow students to learn about their communities and problems, prompting them to brainstorm possible solutions or features that could solve the problems and make the project unique.

Design-Based Learning Activities

Teaching approach designed in this way then allows the use of other principles known from teaching methods such as Design-Based Learning (DBL) (Zhong et al., 2022). However at the same time there are elements known from teaching based on the use of information technology such as blended learning (Jordens et al. 2022; Dare et al. 2021; Learning 2018). Projects can be defined as intensive experiences that engage students in interesting activities that are important to the project study (Nair and Suryan, 2020).

Result

Country with the most research on iSTEM in Project-Based Learning

In fact, there are nine countries involved in this review. According to the study, Malaysia conducted the most integrated STEM. In term of quantity, two studies have been conducted in Malaysia.

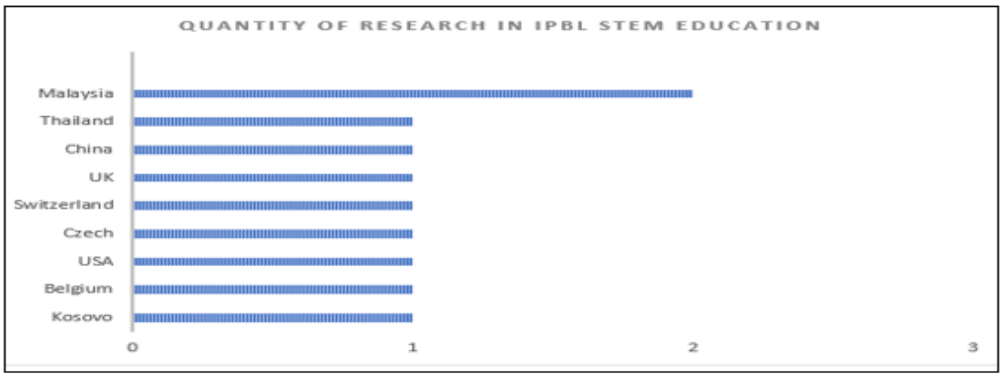

Figure 4. Findings on teaching activities through iSTEM in project-based learning in elementary education research according to the list of countries

Figure 4 illustrate the findings on the teaching activities integrated of STEM in Project-Based Learning in elementary education research according to a list of countries: Thailand, UK, Switzerland, Malaysia, Czech, USA, Belgium, Kosovo and China involved in this research.

Regions where more Studies were Conducted

From the dataset obtained in this study, it can be concluded that non-ASEAN countries are conducting more research than ASEAN countries. Based on the articles selected in this study, Figure 5 represent the percentage of teaching activities though iSTEM in project-based learning for elementary education research in ASEAN and non-ASEAN countries.

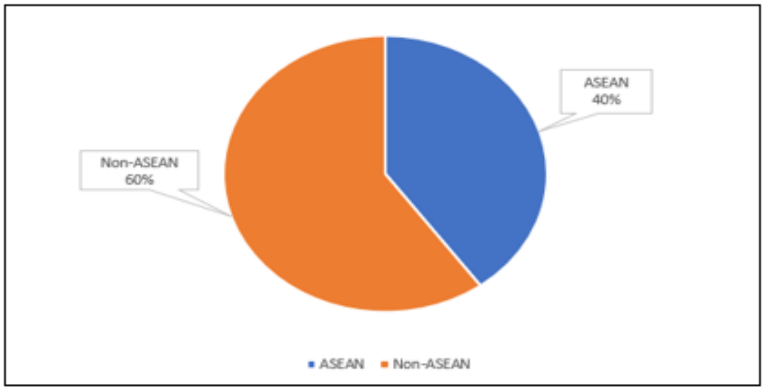

Figure 5. The percentage of teaching activities though iSTEM in project-based learning in elementary education research in ASEAN and non-ASEAN countries

Based on the pie chart above represent about percentage the articles, only 40% of ASEAN countries conducted research to improve the teaching activities though iSTEM in project-based learning at the elementary education. Meanwhile, non-ASEAN countries account for the remaining 60% in iSTEM in project-based learning in elementary education.

Discussions

From the analysis of the studies, it is possible to infer the growing interest among researchers in exploring the relationship between iSTEM in project-based learning in elementary education. The number of studies related to teaching activities through iSTEM that have been presented and evaluated experimentally has shown that there is research conducted in recent years, contributing to this result. In this research, various teaching activities through iSTEM that can be implemented by teachers to improve the knowledge and abilities of students. However, in the development of STEM education through iSTEM, we briefly summarize some of the main literature related to the following areas; iSTEM, there are seven main teaching activities that are user-friendly used among teachers and students though iSTEM education. In the teaching activities through iSTEM teacher have varying ideas related to the STEM disciplines within iSTEM instruction.

There seven teaching activities used when applying iSTEM in project-based learning are Robotic activities, Student-centred learning activities, Inquiry-based learning activities, Project-based cooperative activities, Collaboration project activities, Creative thinking in PBL activities and design-based learning activities used by teachers. The collaboration project, robotic activities and design-based learning activities, can use in teaching and learning. This this study signifies that the teachers and students utilise these activities to develop understanding basic concepts of learning through iSTEM in elementary education. This review also informs us that STEM education though iSTEM in research is growing increasingly with teachers being the primary beneficiaries. This article finding will also be extremely beneficial to teachers to conduct teaching activities, it can provide a clear image of the most effective activities to utilise in integrated STEM in elementary education. In these seven teaching activities of learning, a teacher was required to improve their ability because, without proper preparation, it would be challenging to implement it in teaching more explicitly.

Conclusion

For the current five-year research period, this systematic literature review examined ten papers based on the activities used to STEM education through iSTEM in project-based learning in elementary education. Here, the year of publication indicates the existence of publications of articles on teaching activities though iSTEM, especially after 2022. This indicates that the importance of iSTEM in teaching and learning at the elementary education can still be recognized and there is a need to fill the research gap. Based on the SLR analysis, it was found that the most popular teaching activities used to develop teaching activities through iSTEM in project-based learning capabilities, according to the findings of this study, were robotics coding activities, collaborative projects activities and design-based learning activities. Different teaching activities that include iSTEM need the pedagogical material and play an important role in establishing of iSTEM in process learning in elementary education. Based on the findings of this research, it will be necessary to conduct more research that combines the findings certain teaching activities that are often used to enhance iSTEM in project-based learning abilities in education. However, teacher may be possible to use a greater variety of teaching activities in future studies to assist in the development of STEM education though iSTEM in project-based learning in elementary education.

Limitations and Future Studies

This systematic literature review study gives information on teaching activities through iSTEM in project-based learning in elementary education. These findings have important implication for policymakers and educators. As a result, more thorough investigation must be performed in the near future to tackle the obstacles blocking the improvement of iSTEM abilities in learning instruction. It may be possible to determine if these approaches have a direct influence on improving teaching activities iSTEM in project-based learning or whether they operate as moderators or mediators.

A larger database can also be used to provide further progress in future studies. It is expected that this study would spark further research to improve these abilities, especially in Malaysia and in STEM field.

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References

Abesadze, S., & Nozadze, D. (2020). Make 21st century education: The importance of teaching programming in schools. *International Journal of Learning and Teaching, 6*(3), 158–163.

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project-based learning integrated to STEM to enhance elementary school students' scientific literacy. *Jurnal Pendidikan IPA Indonesia, 5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493

Ahmad, N., & Lajium, D. (2020). Learning environment and interest in STEM career. *International Journal of Modern Education, 2*(6), 28–49. https://doi.org/10.35631/ijmoe.26004

Bascopé, M., & Reiss, K. (2021). Place-based STEM education for sustainability: A path towards socioecological resilience. *Sustainability, 13*(15), 1–16. https://doi.org/10.3390/su13158414

Bates, R., Brenner, B., Schmid, E., Steiner, G., & Vogel, S. (2022). Towards meta–competences in higher education for tackling complex real–world problems: A cross-disciplinary review. *International Journal of Sustainability in Higher Education, 23*(8), 290–308. https://doi.org/10.1108/IJSHE-06-2021-0243

Beardon, T. (2003). Mathematics education for the 21st century. *Springer*. https://doi.org/10.1007/978-3-030-52229-2

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3–4), 369–398.

Bolick, M. A., Thomassen, M., Apland, J., Spencer, O., Nicole, F., Tran, S. K. N., Voigt, M., & Lazar, K. B. (2024). Project-based learning in interdisciplinary spaces: A case study in Norway and the United States. *Education Sciences, 14*(8). https://doi.org/10.3390/educsci14080866

Setiawan, B., Kurniasari, M. R., & Sarkim, T. (2020). The implementation of STEM approach through project-based learning to develop students' creativity. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1470/1/012041

Burrows, A. C., Borowczak, M., Myers, A., Schwortz, A. C., & McKim, C. (2021). Integrated STEM for teacher professional learning and development: "I need time for practice." *Education Sciences, 11*(1), 1–23. https://doi.org/10.3390/educsci11010021

Chan, M. N., & Nagatomo, D. (2022). Study of STEM for sustainability in design education: Framework for student learning and outcomes with design for a disaster project. *Sustainability, 14*(1). https://doi.org/10.3390/su14010312

Chang, C. C., & Chen, Y. K. (2022). Educational values and challenges of i-STEM project-based learning: A mixed-methods study with data-transformation design. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2022.976724

Choque Soto, V. M., Sosa Jauregui, V. D., & Enciso Rodas, L. (2023). Enhancing academic performance in operations research through cooperative PBL in a distance learning environment. *Studies in Applied Economics, 4*(November). https://doi.org/10.46254/sa04.20230021

Dare, E. A., Keratithamkul, K., Hiwatig, B. M., & Li, F. (2021). Beyond content: The role of STEM disciplines, real-world problems, 21st century skills, and STEM careers within science teachers' conceptions of integrated STEM education. *Education Sciences, 11*(11). https://doi.org/10.3390/educsci11110737

Dasgupta, C., Magana, A. J., & Vieira, C. (2019). Investigating the affordances of a CAD-enabled learning environment for promoting integrated STEM learning. *Computers & Education, 129*, 122–142. https://doi.org/10.1016/j.compedu.2018.10.014

Diego-Mantecon, J. M., Prodromou, T., Lavicza, Z., Blanco, T. F., & Ortiz-Laso, Z. (2021). An attempt to evaluate STEAM project-based instruction from a school mathematics perspective. *ZDM Mathematics Education, 53*(5), 1137–1148. https://doi.org/10.1007/s11858-021-01303-9

English, L. D. (2016). STEM education K–12: Perspectives on integration. *International Journal of STEM Education, 3*(1), 1–8. https://doi.org/10.1186/s40594-016-0036-1

Fang, M., Jandigulov, A., Snezhko, Z., Volkov, L., & Dudnik, O. (2021). New technologies in educational solutions in the field of STEM: The use of online communication services to manage teamwork in project-based learning activities. *International Journal of Emerging Technologies in Learning, 16*(24), 4–22. https://doi.org/10.3991/ijet.v16i24.25227

Foski, M., Mrak, G., & Lamovsek, A. Z. (2017). Interdisciplinary approach to project-based learning: Experience through student workshops. *New Trends and Issues Proceedings on Humanities, 5*(5), 95–103.

Holm, M. (2011). Project-based instruction. *Insight: Rivier Academic Journal, 7*(2), 1–13.

Hsu, Y. C., & Shiue, Y. M. (2017). Exploring the community of inquiry in interdisciplinary project-based learning through collaborative technology. *2017 IEEE International Conference on Applied System Innovation (ICASI)*. https://doi.org/10.1109/ICASI.2017.7988289

Hussin, H., Jiea, P. Y., Rosly, R. N. R., & Omar, S. R. (2019). Integrated 21st century STEM education through robotics project-based learning. *Humanities and Social Sciences Reviews, 7*(2), 204–211. https://doi.org/10.18510/hssr.2019.7222

Imbaquingo, A., & Cárdenas, J. (2023). Project-based learning as a methodology to improve reading and comprehension skills in the English language. *Education Sciences, 13*(6). https://doi.org/10.3390/educsci13060587

Jordens, X., Wilmart, R., Garone, E., Kinnaert, M., & Catoire, L. (2022). A project-based learning approach for building an affordable control teaching lab: The centrifugal ring positioner. *IEEE Access*. https://doi.org/10.1109/ACCESS.2022.3141588

Keleman, M. (2021). Assessment of higher order thinking skills through STEM integration project-based learning for elementary level. *International Journal of Social Science and Human Research, 4*(4), 835–846. https://doi.org/10.47191/ijsshr/v4-i4-40

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1). https://doi.org/10.1186/s40594-016-0046-z

Ketelhut, D. J., Mills, K., Hestness, E., Cabrera, L., Plane, J., & McGinnis, J. R. (2020). Teacher change following a professional development experience in integrating computational thinking into elementary science. *Journal of Science Education and Technology, 29*(1), 174–188. https://doi.org/10.1007/s10956-019-09798-4

Kraus, S., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal, 16*(4), 1023–1042. https://doi.org/10.1007/s11365-020-00635-4

Learning, Project-based. (2018). Project-based learning: An interdisciplinary approach. *Project-Based Learning Journal, 2501*, 1–5.

Lin, K. Y., Hsiao, H. S., Chang, Y. S., Chien, Y. H., & Wu, Y. T. (2018). The effectiveness of using 3D printing technology in STEM project-based learning activities. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(12). https://doi.org/10.29333/ejmste/97189

Luo, T., Zhao, J., & So, W. W. M. (2022). Students' reflections on their scientist- or engineer-like practices in STEM project-based learning. *Journal of Baltic Science Education, 21*(1), 119–130.

Major, S., Hubálovská, M., & Loskot, R. (2022). Alternative forms of laboratory teaching during the lockdown period caused by the COVID-19 pandemic. *International Journal of Information and Education Technology, 12*(11), 1137–1147. https://doi.org/10.18178/ijiet.2022.12.11.1731

McKay, H. F. (2024). Empowering principals to lead project-based learning with students historically underrepresented in STEM. *Interdisciplinary Journal of Problem-Based Learning, 18*(1).

Mohamad, N. A., Mat Nor, K., Nurzatulshima, A., Umi Kalthom, A. M., & Hazwan, M. P. M. (2017). Penerapan kemahiran berfikir aras tinggi (KBAT) dalam kurikulum reka bentuk dan teknologi (RBT) sekolah rendah. *International Journal of Education and Training, 3*(2), 1–7.

Moore, T. J., Glancy, A. W., Tank, K. M., Kersten, J. A., Smith, K. A., & Stohlmann, M. S. (2014). A framework for quality K-12 engineering education: Research and development. *Journal of Pre-College Engineering Education Research, 4*(1). https://doi.org/10.7771/2157-9288.1069

Nair, M. G., & Suryan, A. (2020). Trans-disciplinary project-based learning models for community service. *Procedia Computer Science, 172*, 735–740. https://doi.org/10.1016/j.procs.2020.05.105

Nava, I., & Park, J. (2021). Pre-service STEM teachers and their enactment of community-STEM-project-based learning (C-STEM-PBL). *Journal of Higher Education Theory and Practice, 21*(9), 217–237. https://doi.org/10.33423/jhetp.v21i9.4602

Oyewo, O. A., Ramaila, S., & Mavuru, L. (2022). Harnessing project-based learning to enhance STEM students' critical thinking skills using a water treatment activity. *Education Sciences, 12*(11). https://doi.org/10.3390/educsci12110780

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Prishtina, H. (2023). mBot robot as part of project-based learning in STEM. *Revista Educación, 862–872*.

Sahin, A., & Top, N. (2015). STEM students on the stage (SOS): Promoting student voice and choice in STEM education through an interdisciplinary, standards-focused, project-based learning approach. *Journal of STEM Education, 16*(3), 24–34. http://jstem.org/index.php?journal=JSTEM&page=article&op=viewFile&path[]=1911&path[]=1683

Santaolalla, E., Urosa, B., Martín, O., Verde, A., & Díaz, T. (2020). Interdisciplinarity in teacher education: Evaluation of the effectiveness of an educational innovation project. *Sustainability, 12*(17). https://doi.org/10.3390/su12176748

Seo, S., Van Orman, D. S. J., Beattie, M., Paxson, L. C., & Murray, J. (2024). Interdisciplinary project-based learning. *Education Sciences*.

Siew, N. M., & Ambo, N. (2020). The scientific creativity of fifth graders in a STEM project-based cooperative learning approach. *Problems of Education in the 21st Century, 78*(4), 627–643. https://doi.org/10.33225/pec/20.78.627

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. (2019). Students' engagement in different STEM learning environments: Integrated STEM education as promising practice? *International Journal of Science Education, 41*(10), 1387–1407. https://doi.org/10.1080/09500693.2019.1607983

Sukamti, U., Putra, A. P., & Devi, A. C. (2019). Innovation of project-based learning (PjBL) on outdoor study for PGSD's student activity on education diffusion. *International Journal of Innovation, Creativity and Change*.

Sulaiman, F., Rosales, J. J., & Lee, J. K. (2024). The effectiveness of integrated science, technology, engineering and mathematics project-based learning module. *International Journal of Evaluation and Research in Education, 13*(3), 1740–1754. https://doi.org/10.11591/ijere.v13i3.26676

Sutaphan, S., & Yuenyong, C. (2023). Enhancing grade eight students' creative thinking in the water STEM education learning unit. *Cakrawala Pendidikan, 42*(1), 120–135. https://doi.org/10.21831/cp.v42i1.36621

Syahril, P., Wulansari, R. E., Nabawi, R. A., Safitri, D., & Kiong, T. T. (2022). The effectiveness of project-based learning on 4Cs skills of vocational students in higher education. *Journal of Technical Education and Training, 14*(3), 29–37. https://doi.org/10.30880/jtet.2022.14.03.003

Tang, K. S., McLure, F., Williams, J., & Donnelly, C. (2024). Investigating the role of self-selected STEM projects in fostering student autonomy and self-directed learning. *Australian Educational Researcher, 51*(5), 2355–2379. https://doi.org/10.1007/s13384-024-00696-2

Tytler, R., Swanson, D. M., & Appelbaum, P. (2015). Subject matters of science, technology, engineering, and mathematics. In M. F. He, B. D. Schultz, & W. H. Schubert (Eds.), *The SAGE guide to curriculum in education* (pp. xxx–xxx). SAGE Publications.

Uddin, S., Imam, T., & Mozumdar, M. (2021). Research interdisciplinarity: STEM versus non-STEM. *Scientometrics, 126*(1), 123–145. https://doi.org/10.1007/s11192-020-03750-9

Wahyuni, S., Mujiyanto, J., Rukmini, D., & Fitriati, S. W. (2020). Teachers' technology integration into English instructions: SAMR model. *Advances in Social Science, Education and Humanities Research*. https://doi.org/10.2991/assehr.k.200620.109

Wan Rashid, W. H., Che Kob, C. G., & Abdullah, A. S. (2020). Modul pembelajaran berasaskan projek: Kesan terhadap pencapaian teori dalam projek tahun akhir 1 di kolej vokasional. *Journal of Vocational Education Studies, 3*(1). https://doi.org/10.12928/joves.v3i1.1409

Widiyanti, M., Eddy, D. L., & Yoto. (2020). Project-based learning based on STEM (science, technology, engineering, and mathematics) to develop the skill of vocational high school students. *2020 4th International Conference on Vocational Education and Training (ICOVET)*. https://doi.org/10.1109/ICOVET50258.2020.9230088

Winarni, E. W., Karpudewan, M., Karyadi, B., & Gumono, G. (2022). Integrated PjBL-STEM in scientific literacy and environmental attitude for elementary school. *Asian Journal of Education and Training, 8*(2), 43–50. https://doi.org/10.20448/edu.v8i2.3873

Wood, D., & Pranjol, M. Z. I. (2024). Buddychecking: A way to enhance student participation in bioscience project-based learning. *Education Sciences, 14*(10). https://doi.org/10.3390/educsci14101103

Yulhendri, Y., Sakti, M. R. P., Sofya, R., Ritonga, M., Alisha, W. P., Sudjatmoko, A., & Susanti, N. (2023). Strategies for project-based learning during the pandemic: The benefits of reflective learning approach. *SAGE Open, 13*(4), 1–18. https://doi.org/10.1177/21582440231217885

Zhong, B., Liu, X., Xia, L., & Sun, W. (2022). A proposed taxonomy of teaching models in STEM education: Robotics as an example. *SAGE Open, 12*(2). https://doi.org/10.1177/21582440221099525