International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

INTERNATIONAL JOURNAL OF MODERN EDUCATION (IJMOE)
www.ijmoe.com

GLOBAL ACADEMIC EXCELLENCE

STEAM INNOVATION: CURRICULUM ALIGNMENT, EXPERIENTAL LEARNING, AND TRANSDISCIPLINARY APPROACHES

Suraya Zakaria[1], Siti Zuraidah Md Osman[2*]

[1] School of Educational Studies, Universiti Sains Malaysia
Email: zsuraya@student.usm.my
[2] School of Educational Studies, Universiti Sains Malaysia
Email: sitizuraidah@usm.my
[*] Corresponding Author

Article Info:

Article history:
Received date: 27.06.2024
Revised date: 17.07.2022
Accepted date: 28.08.2024
Published date: 30.09.2024

To cite this document:

Zakaria, S., & Osman, S. Z. M. (2024). Steam Innovation: Curriculum Alignment, Experiental Learning, And Transdisciplinary Approaches. *International Journal of Modern Education, 6* (22), 319-335.

DOI: 10.35631/IJMOE.622024

Abstract:

The inventive teaching approaches, such as project-based learning, combining arts with Science, Technology, Engineering and Mathematics (STEM) subjects, as well as adopting technology like three dimensional (3D) printing and Internet of Things (IoT) can significantly improve students' involvement, motivation, and creative thinking ability. Integrating Science, Technology, Arts, Engineering, and Mathematics (STEAM) education creates a constructive way of nurturing creativity and enhancing problem-solving skills. Students are encouraged to think critically through hands-on activities and collaborative projects. Nevertheless, an effective study was lacking which systematically revised the existing literature on primary school to identify, develop, and apply innovative methodologies and practices in STEAM education to improve creativity, critical thinking, and problem-solving skills across diverse educational contexts and populations. Therefore, this paper performs a systematic literature review to enhance creativity and problem-solving skills and its enhancement in various contexts and demographics. The present study examines techniques and practices in STEAM education using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The present study chose articles for analysis using two well-scoped databases, Scopus as well as Web of Science (WoS). This review had three main themes arising from the thematic analysis: 1) innovative methodologies and practices in STEAM education, 2) enhancing creativity and problem-solving through STEAM, and 3) STEAM education in diverse contexts and populations. Key results were that integrated STEAM education is most effective in education in primary school curricula, which significantly improves creativity and problem-solving skills and benefits, including those in disadvantaged areas and disabled students, through tailored curricula and teaching methods that promote inclusivity. These highlights could be very

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

helpful for teachers to receive proper training in STEAM education and successfully foster creativity within design and technology education.

Keywords:

Creativity, Design and Technology Education, Primary School, Teacher

Introduction

Generally, traditional STEM education focuses primarily on scientific and mathematical disciplines (Tytler, 2020). Rodrigues-Silva & Alsina, (2023) highlighted the most studies are more focused on environmental sustainability and how to deal with it, but there is a lack of teaching that involves knowledge and skills in sustaining STEM/STEAM fields. According to Anisimova et al., (2020), only 18% of future teachers are aware of STEM and STEAM education programs, and only 10% believe that they are ready to lead the project activities. Real-world STEAM education incorporates the arts into these disciplines, emphasizing creativity and holistic learning (Belbase et al., 2022). Educators and policymakers have increasingly recognized this inclusive approach for its capability to adopt critical thinking, creativity, as well as problem-solving amongst students as the qualities are deemed necessary for the challenging adventures paving the way in a modern globalized world. Thematic learning activities are among the approaches that can foster creative thinking, group communication, collaboration and critical thinking skills of students (Ye & Xu, 2023).

This study has explored 18 academic papers in STEAM education that discuss how the growth of creativity as well as critical thinking skills is affected by the use of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The study focuses on the discovery, screening, and assessment of relevant research to highlight innovative methodologies and practices in STEAM education that encourage creativity and problem-solving in different contexts. Moreover, it explores the significance of adapting the STEAM curriculum to accommodate diverse learning needs and ensure equitable access to high-quality education, especially for students who are categorized as having disabilities. The adaptation of the STEAM curriculum is important to accommodate diverse learning needs and ensure equitable access especially to students with disabilities in guaranteeing high quality education (Truong Thi & Dinh Nguyen Trang, 2022).

This study aims to provide insightful viewpoints on the efficacy of various instructional approaches in STEAM education, with mainly emphasise on the significance of inclusivity and creativity. The findings offer valuable insights into the ways in which differentiated instruction, assistive technologies, and tailored learning plans might be used to establish an inclusive learning environment. These findings will be advantageous to educators, policymakers, and academics in discerning the most efficient approaches and opportunities for STEAM education (Li et al., 2022).

Literature Review

The literature evaluation will encompass five essential aspects. The discussion included enhanced creativity through STEAM integration, project-based learning (PBL) and creative thinking, critical thinking through Inquiry-Based Learning (IBL), cross-disciplinary collaboration, and innovative pedagogical approaches. The integration of STEAM education

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024
has been commended for its ability to foster innovative and critical thinking skills. This literature review examines recent studies to elucidate how STEAM education fosters these essential skills, with a particular focus on innovative pedagogical approaches and their impact on student performance.

Enhanced Creativity Through STEAM Integration

Recent research repeatedly demonstrates that the incorporation of arts into STEM fields has a substantial positive impact on students' creativity. In a study conducted by Okwara & Henrik Pretorius (2023)**,** it was discovered that engaging elementary pupils in STEAM projects that incorporated visual arts resulted in increased levels of divergent thinking. According to Conradty et al. (2020), creativity in the STEAM module can promote self-efficacy, and further increase career motivation and creativity in the science classroom. Cheng et al. (2022) showed that when middle school students participated in science sessions that incorporated music, they demonstrated improved creative problem-solving skills. These highlight the positive relationship between the arts and STEM subjects. At the same time, Yin (2021) highlighted the integrating design thinking into STEAM education can increase students' creativity and problem-solving abilities in STEAM subjects.

Project-Based Learning (PBL) And Creative Thinking

PBL remains a potent driver of innovative thinking in the context of STEAM education. Ibrahim Mohammed Elfeky, Mohammed Alharbi, & Sultan Abdul Hameed Ahmed (2022) found that students who engaged in STEAM PBL activities had significant enhancements in creativity, namely in the generation and refinement of original ideas. Chang et al., (2023) stated that integrating STEAM into project-based learning can improve students' creativity and computational skills. The emphasis of PBL on real-world applications and iterative design processes creates an ideal environment for nurturing creativity. Gupta (2022) presented that integrating design-based learning and project-based learning in software engineering courses can positively influence student learning, engagement and performance.

Critical Thinking Through Inquiry-Based Learning (IBL)

IBL continues to be a fundamental aspect of STEAM education, promoting the development of critical thinking abilities. Research conducted by Isdianti, Nasrudin, & Erman (2021) showed that high school students who participated in STEAM IBL projects had enhanced critical analysis skills in comparison to those who were taught using conventional instructional approaches. The iterative questioning, data analysis, and evidence-based reasoning that is inherent in IBL play a crucial role in fostering critical thinking. The implementation of inquiry-based learning can significantly improve the critical thinking skills of potential teachers, especially those who like to use their knowledge and skills practically (Dewi, Ardhana, Irtadji, Chusniyah, & Sulianti, 2021) . Ahmed Dool et al. (2021) underscored the inquiry-based learning (IBL) in the elementary grades can improve literacy and science skills that focus on active engagement and critical thinking in real-world expressions and practices.

Cross-Disciplinary Collaboration

STEAM education is increasingly acknowledging the importance of cross-disciplinary collaboration. A study conducted by Hebebci & Usta (2022) emphasized that collaborative STEAM projects stimulate students to combine knowledge from several disciplines, fostering the development of critical assessment and synthesis of information. This collaborative approach not only improves critical thinking but also equips students with the interdisciplinary

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

character of contemporary concerns. Collaborative learning also has a positive impact on students' critical thinking skills, emotions, learning motivation, cognitive development and broad thinking for students (Warsah, Morganna, Uyun, Hamengkubuwono, & Afandi, 2021).

Innovative Pedagogical Approaches

In recent years, some new and creative teaching methods have been developed. Virtual Reality (VR) and Augmented Reality (AR) technology are being combined with STEAM curricula to provide immersive learning experiences. A study conducted by Velarde-Camaqui, Celaya-Ramírez, Contreras-Fuentes, & Sanabria-Z (2024) discovered that VR focused on STEAM had a substantial impact on improving creative and critical thinking abilities. It was achieved by offering dynamic and captivating environments that encouraged exploration and experimentation. With AR media in STEAM learning can increase interest, motivation and provide experience to elementary students (Rukayah et al., 2022). AR and VR in education can increase students' knowledge, engagement, motivation and provide experiences that nurture the generation to be more skilled in the field of technology (AlGerafi, Zhou, Oubibi, & Wijaya, 2023).

Table 1: Summary Of Past Findings

Author (Year)	Title	Concept/Theory/ Theoretical Frameworks	Finding
Okwara & Henrik Pretorius (2023)	The STEAM vs STEM Educational Approach: The Significance of the Application of the Arts in Science Teaching for Learners' Attitudes Change	- STEAM integrates arts and science for holistic learning experience. - STEM focuses on objective evidence, while arts emphasize personal experience. - Transdisciplinary approach in STEAM fosters creativity and problem-solving skills.	- Incorporating arts in STEM enhances creativity, attitudes, and interest in science. - Puppetry art in education improves STEM learners' engagement and performance.
Conradty et al., (2020)	How Creativity in STEAM Modules Intervenes with Self-Efficacy and Motivation	- Creativity fosters motivation and self-efficacy in STEAM educational settings. - Act and flow are cognitive variables associated with creativity. - Self-efficacy beliefs are task-specific and influenced by contextual factors.	- Self-efficacy significantly increased, no age or gender effects observed. - Act creativity factor increased, while Flow factor did not change. - No gender impact or age effect on monitored variables observed.
Cheng, L., Wang, M., Chen, Y., Niu, W., Hong, M., & Zhu, Y. (2022)	Design My Music Instrument: A Project-Based Science, Technology, Engineering, Arts, and Mathematics Program on The	- Creativity defined as producing novel and appropriate outcomes by experts. - Guilford's divergent thinking theory used to assess creativity in students.	- Project-based STEAM program significantly improved elementary students' creativity over 6 weeks. - Multi-method approach confirmed the

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

	Development of Creativity	- Multi-approach measurement of creativity used to capture students' creativity effectively.	effectiveness of the educational program. - PBL and integrative approach in science education enhance student creativity.
Yin, X (2021)	Integrating Design Thinking Into STEAM Education: The Design Of STEAM Education Platform And Course Based On Creativity Elements	- Design thinking integrates creativity into STEAM education for problem-solving skills. - Creativity elements like curiosity, flexibility, and risk-taking enhance academic performance. - Design thinking promotes creativity and problem-solving skills in education.	- Creativity dimensions impact academic performance positively. - Creativity elements enhance STEAM education platform design effectively.
Ibrahim Mohammed Elfeky, A., Mohammed Alharbi, S., & Sultan Abdul Hameed Ahmed, E. (2022)	The Effect Of Project-Based Learning In Enhancing Creativity And Skills Of Arts Among Kindergarten Student Teachers	- PBL enhances creativity and arts skills. - Creativity defined as novel, appropriate responses to open-ended tasks. - PBL positively influences creativity and arts skills development among teachers.	- PBL enhances creativity through idea manipulation and generation. - PBL improves arts skills through esthetic and creative aspects. - SEM shows PBL positively impacts creativity and arts skills.
Chang, C.-Y., Du, Z., Kuo, H.-C., & Chang, C.-C. (2023)	Investigating The Impact Of Design Thinking-Based STEAM PBL On Students' Creativity And Computational Thinking	- Tri-phase DT-PBL integrates DT, PBL, and creative thinking. - STEAM PBL enhances creativity and computational thinking skills in students. - DT-PBL framework cultivates creativity and computational thinking in junior high students.	- STEAM PBL enhanced creativity and computational thinking in students significantly. - Experimental group excelled in creativity dimensions like fluency, flexibility, and originality. - No significant improvements in creativity were observed in the comparison group. - Computational thinking improved in the experimental group for medium and hard tasks.

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Gupta, C. (2022)	The Impact And Measurement of Today's Learning Technologies In Teaching Software Engineering Course Using Design-Based Learning And Project-Based Learning	- DBL and PBL used to teach software engineering course. - Focus on critical thinking and creativity in software systems design.	- Positive impact on student knowledge, understanding, and performance. - DBL and PBL help meet industry challenges and course outcomes.
Isdianti, M., Nasrudin, H., & Erman, E. (2021)	The Effectiveness Of STEM Based Inquiry Learning Packages To Improving Students' Critical Thinking Skill	- STEM-based inquiry learning enhances critical thinking skills in students. - Critical thinking involves reflective, reasonable thinking to evaluate evidence and assumptions.	- STEM-based inquiry learning improves students' critical thinking skills. - Analysis shows effectiveness of STEM-based 5M inquiry learning packages.
Dewi, D. K., Ardhana, W., Irtadji, Chusniyah , T., & Sulianti, A. (2021)	Inquiry-Based Learning Implementation To Improve Critical Thinking Of Prospective Teachers	- Bloom's taxonomy classifies thinking skills into LOTS and HOTS. - Learning styles theory emphasizes individual modes for effective learning. - Mismatch theory suggests curiosity arises from violated expectations.	- Critical thinking improved significantly with IBL method compared to PBL. - Prospective teachers with converging learning styles showed higher critical thinking increase. - Both IBL and PBL groups showed increased critical thinking skills.
Ahmed Dool, M., Akhtar, N., & Khan, N. (2021)	Inquiry-Based Learning Practices for Science Teaching in Elementary Grades: A Literature Review of the Asian Countries	- IBL as a student-centered approach in science. - IBL enhances students' active engagement, investigation, reflection, and critical thinking. - Student-centered teaching methods like IBL improve science process skills. - IBL influences practical skills development in junior high school students. - IBL intervention improves basic science process skills in students.	- IBL enhances science skills and literacy in elementary grade students. - IBL intertwines with science learning, promoting inquiry and comprehension. - 5E model improves comprehension and application abilities in science students. - IBL approach develops critical thinking skills in grade 6 students.
Hebebci, M. T., &	The Effects Of Integrated STEM Education Practices	- STEM education integrates science, technology, engineering,	- Integrated STEM education enhances problem-solving skills,

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Usta, E. (2022)	On Problem Solving Skills, Scientific Creativity, And Critical Thinking Dispositions	and mathematics disciplines. - STEM focuses on collaborative learning and covers formal and informal education.	scientific creativity, and critical thinking. - STEM practices positively impact students' problem-solving abilities.
Warsah, I., Morganna, R., Uyun, M., Hamengkubuwono, H., & Afandi, M. (2021)	The Impact Of Collaborative Learning On Learners' Critical Thinking Skills	- Collaborative Learning (CL) model integrates critical thinking, motivation, and social competence. - CL enhances cognitive development, emotional awareness, and learning motivation. - Learners' perspectives on CL highlight emotional awareness and cognitive development.	- Collaborative learning enhances critical thinking, cognitive abilities, and learner motivation.
Velarde-Camaqui, D., Celaya-Ramírez, R., Contreras-Fuentes, Y., & Sanabria-Z, J. (2024)	Enhancing STEAM Education Through Augmented Reality: The EduAR Open Platform Experience	- Design-Based Research (DBR) methodology for EduAR platform development. - Open Educational Resources (OER) movement for equitable access to education.	- AR enhances STEAM learning effectively. - EduAR promotes equitable access to quality educational resources. - DBR improves AR educational platforms. - EduAR fosters problem-solving and critical thinking skills in students.
AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023)	Unlocking The Potential: A Comprehensive Evaluation Of Augmented Reality and Virtual Reality in Education	- Theoretical framework enhances application effectiveness in addressing learning objectives. - Infusing pedagogical theories bridges gaps in educational application design.	- AR and VR enhance student learning, engagement, and motivation. - Impact of AR and VR on student academic performance and outcomes.

Objectives

- To develop and implement innovative approaches that harmonize STEAM projects with national curriculum requirements using "forward" and "backward" design techniques. This alignment ensures that STEAM education is both progressive and compliant with educational standards, fostering an integrative learning environment that meets national benchmarks.
- To focus on employing experiential, student-centered instructional methods, such as the 5E approach (Engage, Explore, Explain, Elaborate, and Evaluate) and PBL. This

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

method is designed to cultivate creativity, excitement, and problem-solving abilities in students by engaging them in hands-on, real-world projects that promote active learning and critical thinking.

- To incorporate advanced technologies, for example, data science, the IoT, and digital tools into STEAM education. The goal is to enhance critical thinking, creativity, and transdisciplinary learning by leveraging these technologies to create immersive and interactive learning experiences that bridge multiple disciplines and prepare students for complex, technology-driven environments.

Methodologies

This systematic literature review utilised the guidelines defined by the PRISMA statement. It has been updated reporting guidance that incorporates advancements in methodologies for identifying, screening, eligibility, and data abstraction and analysis, as well as quality control procedures associated with a review (Page et al., 2021).

Identification

As per our research questions, we identified four main keywords: creativity, design and technology education, primary school, and teacher. In order to complement these keywords, the authors have checked their synonyms or related terms and variations in an online "thesaurus"; they have also reviewed keywords used by previous studies, according to suggestions of Scopus as well as WoS, and also by asking the opinion of experts. Search strings for the databases Scopus and WoS (refer to Table 2) have been developed following the selection of all pertinent terms. A total of 109 potential articles were identified from the selected databases based on searching efforts during the first stage of the systematic review process.

Table 2: Search String Used In The Selected Database

Scopus	TITLE-ABS-KEY (("creativity" OR "innovation" OR "creative thinking" OR "creative skills") AND ("design and technology education" OR "D&T education" OR "design education" OR "technology education" OR "STEM education" OR "STEAM education") AND ("teacher" OR "educator" OR "instructor" OR "teaching professional") AND ("primary school" OR "elementary school" OR "primary education" OR "elementary education" OR "K-5 education" OR "K-6 education")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))
WoS	("creativity" OR "innovation" OR "creative thinking" OR "creative skills") AND ("design and technology education" OR "D&T education" OR "design education" OR "technology education" OR "STEM education" OR "STEAM education") AND ("teacher" OR "educator" OR "instructor" OR "teaching professional") AND ("primary school" OR "elementary school" OR "primary education" OR "elementary education" OR "K-5 education" OR "K-6 education") (Topic)

Source: June 2024 (Scopus And WoS)

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Screening

Considering the eligibility criteria of PRISMA, this review is limited to the screening process, which only includes the articles published for a five-years period between 2020 until 2024. In the pre-screening phase, duplicate papers were omitted. By means of inclusion-and-exclusion criteria formulated by researchers, 86 papers were excluded in the first phase, whereas 23 articles were evaluated in the second phase. Moreover, the publications in terms of conference proceedings, chapters, books, book series, meta-synthesis, meta-analyses, reviews, as well as systematic reviews are out of the scope of this study. Note that the analysis was restricted to English-language studies; no limitations were imposed on the type of study conducted. We will be using worldwide research to accomplish our analytical purpose. Correspondingly, 18 publications based on predetermined criteria have been selected overall.

Table 3: The Selection Criterion In Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline / Years	2020 – 2024	< 2020
Literature Type	Journal (Article)	Review, Book, Conference,
Publication Stage	Final	In Press

Source: June 2024 (Scopus And WoS)

Eligibility

In the third phase, eligibility, an expert review of content is also conducted to ensure that all articles retrieved (after screening) meet the criteria. This was done by scanning the title and abstracts of the articles. The last 19 articles are modeled on the third step. Titles and key content of all relevant articles were then scrutinized to ascertain that the inclusion criteria were met and that they pertained to this study with our research objectives at present. Therefore, one report was excluded because the title is not significant. Overall, there were only 18 selected articles for review (refer to Table 3).

Data Abstraction and Analysis

As a kind of evaluation, this study applied integrative analysis to comprehensively investigate and combine several research approaches, which includes mixed, qualitative, as well as quantitative methodologies. The purpose of the professional examination was to determine certain issues and sub-issues. Data collection was the first step in developing themes. It is displayed in Figure 1 and reflects an examination across a total of 18 publications representing statements or content relevant to the scope of this study.

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

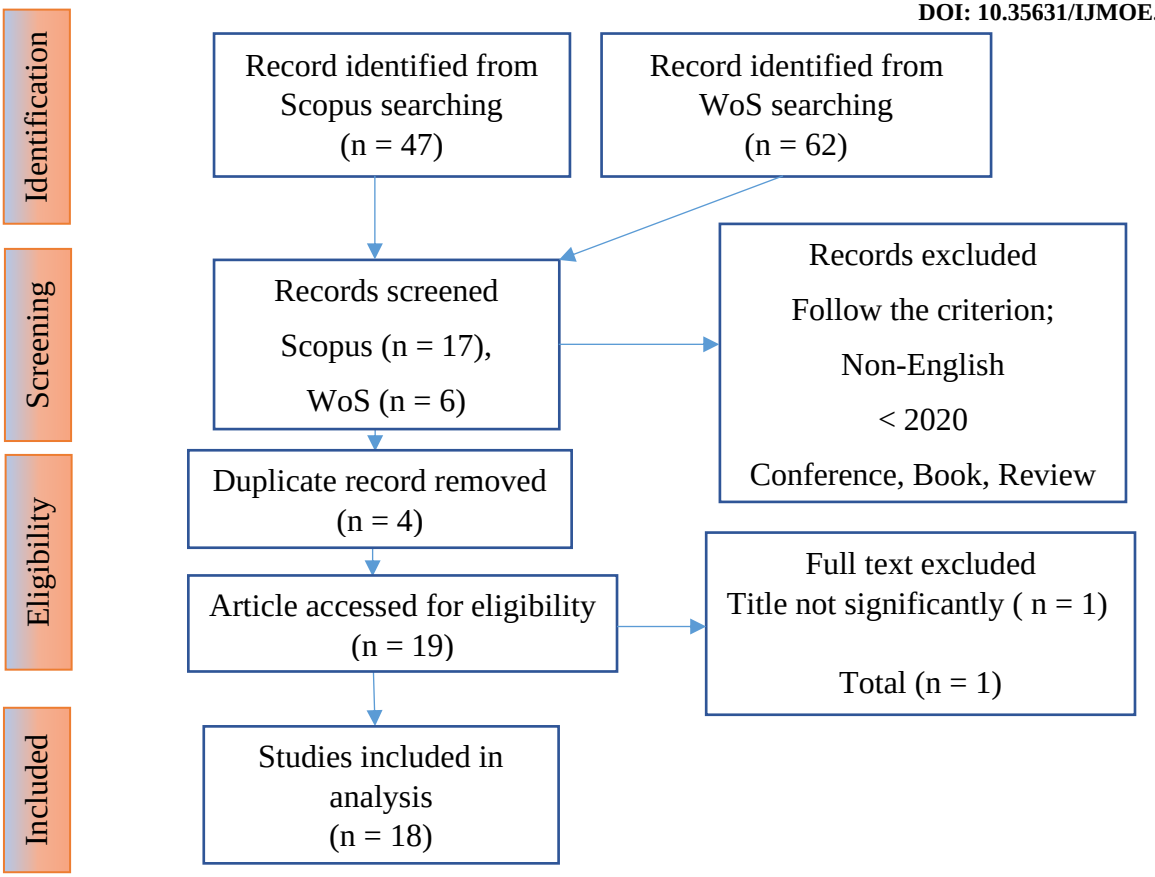

Figure 1: Flow Diagram with regard to The Proposed Searching Study
Source: (Scopus And WoS)

Consequently, the writers reviewed existing key papers about primary school education. An investigation into the methodology used in all investigations and research findings is underway. Next, the author and another co-author collaborated to determine themes that could be created based on the evidence discussed in this study. A log was kept during the analysis process that included records of any puzzles, perspectives, analyses, or other thoughts pertinent to the data interpretation. Subsequently, the authors compared data, looking for inconsistencies in the design of the theme. It is worth mentioning that in the case where opinions on notions differ, authors discuss this amongst themselves. The generated themes were ultimately adjusted to guarantee uniformity. Two experts conducted the analysis selection. One specialized in economics, business, and management with 10 years of experience in Technical and Vocational Education and Training (TVET), and the other specialized in social science with 10 years of experience in TVET. Their purpose was to assess the accuracy of the identified issues. The expert review step of constructing the domain assesses that every subtheme is clear, relevant, and appropriate.

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Result and Finding

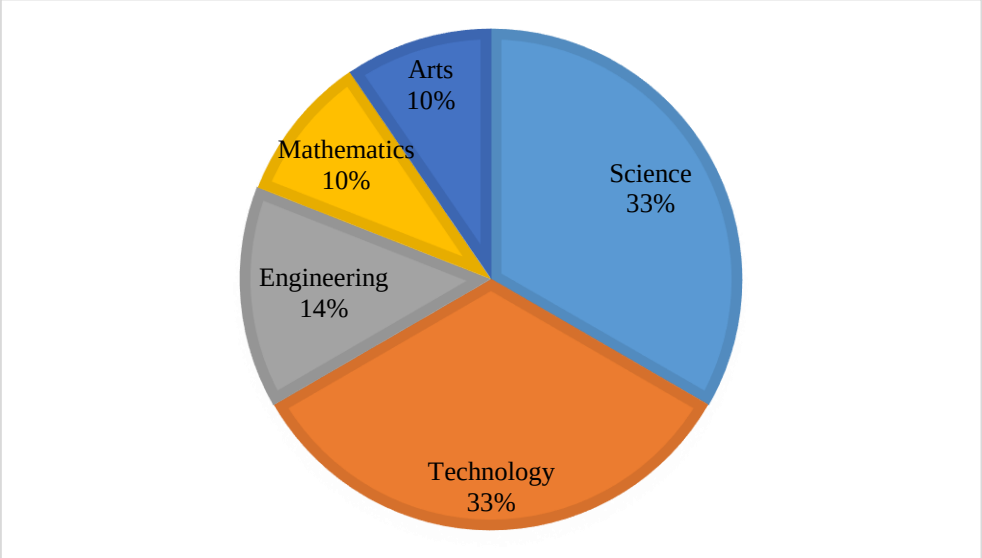

Figure 2: Findings of the STEAM Integration

Recent research has focused on exploring innovative techniques and practices in STEAM education, which have provided significant potential for the teaching-learning process. Breda, Garcia, & Santos (2023) introduce a creative strategy for creating STEAM projects that align with national curricula. They employ "forward" and "backward" methods to find opportunities within the curriculum and areas for project development. Ozkan & Umdu Topsakal (2021) highlights the benefits of STEAM education compared to traditional approaches, demonstrating its capacity to foster creativity and enthusiasm via hands-on, student-centered learning. Nguyen Thi Thu, Tran Ngoc, & Nguyen (2023) suggest implementing the 5E approach in elementary education. They advise using the topic "My Green Garden" to foster problem-solving skills and creativity through thematic learning. In their 2019 publication, Wu, Guo, and Zhu present a data-collecting model for 3D printing classes that utilizes the xAPI standard. The primary objective of this model is to assess students' spatial thinking and engineering design abilities. Lu, Wu, & Huang (2022) examine the effects of PBL focused STEAM curriculum on children with learning difficulties, emphasizing notable enhancements in creativity and academic achievements. Liston, Morrin, Furlong, & Griffin (2022) investigate the incorporation of data science and the IoT into STEAM education in Ireland. They aim to encourage transdisciplinary learning by utilizing innovative technology. These studies demonstrate the various inventive methods to promote STEAM education, which boosts creativity, problem-solving abilities, and overall learning experiences.

Facilitating creativity and problem-solving skills through STEAM education requires integrating many pedagogical approaches, digital tools, and innovative initiatives. In their study, Love, Napoli, & Lee (2023) examine the effects of incorporating science and poetry into the training of future teachers on their confidence in teaching science. The researchers compare the outcomes of online and face-to-face approaches and discover substantial advantages in both formats. Vasylykiv Ivan (2024) emphasize the significance of contemporary information technology in professional education, demonstrating how digital tools can augment critical thinking and creativity among prospective primary school educators. Lage-Gómez & Ros (2024) examine the connections between different types of creativity in STEAM projects in

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024
primary education. They use graph theory to investigate the cognitive and conative aspects. Arabit-Garcia, Prendes-Espinosa, & Serrano (2023) assess the utilization of free educational materials and active methodologies in STEM instruction, highlighting their efficacy in promoting creativity and problem-solving abilities. Phonnong & Keeratichamroen (2023) comprehensively analyze the difficulties and advantages of distance STEAM education during the COVID-19 outbreak at a disadvantaged primary school in Thailand. They emphasize the influence of this approach on students' capacity for creativity and problem-solving. Aydin (2020) highlights the crucial requirements that elementary school instructors must fulfill before implementing STEM education. The author emphasizes the significance of utilizing integrated, problem-based learning methods. These studies highlight the crucial importance of using innovative teaching techniques and digital tools to improve creativity and problem-solving abilities in STEAM education.

Several studies emphasize the impacts of innovative techniques in STEAM education on distinct environments and people across different educational stages. Zviel-Girshin, Luria, & Shaham (2020) examine the application of robots in early childhood education to promote technological cognition and crucial abilities for the 21st century, highlighting the significance of early engagement with technology. Bautista (2021) presents essential empirical data regarding the credibility and efficacy of STEAM education, emphasizing the need for both theoretical and practical research to facilitate its extensive adoption. Robb (2024) surveyed primary school teachers in Scotland, which highlighted a significant demand for improved training and professional development in art instruction to increase educational outcomes. Martinez-Jimenez, Nolla de Celis, & Fernandez-Ahumada (2022) propose the utilization of urban surroundings as educational resources by employing problem-posing and Math Trails. They provide evidence of the positive impact of contextual learning on the improvement of mathematical comprehension. In this study, Schut, van Mechelen, Klapwijk, Gielen, & de Vries (2022) examine the effects of guided feedback on promoting creative thinking in young, inexperienced designers. They emphasize the significance of constructive design feedback dialogues. In addition, Chen (2023) assesses the relationships between universities and schools in implementing game-based learning and discovers notable advantages in developing creative thinking. These studies provide a thorough perspective on how STEAM education can be successfully tailored to different circumstances and demographics, strengthening its capacity to enhance instructional methods in a wide range of environments.

Discussion

Current research has concentrated on pioneering methods and strategies in STEAM education, uncovering noteworthy progress in instructional and educational procedures. Montes et al. (2023) present an innovative approach to harmonize STEAM projects with the national curriculum by employing "forward" and "backward" techniques to find potential project opportunities. Hoi (2021) underscores the advantages of STEAM education compared to traditional approaches, emphasizing its ability to cultivate creativity and excitement through experiential, student-centered instruction. Nguyen Thi Thu et al. (2023) propose using the 5E approach in elementary education. They suggest employing the subject "My Green Garden" to foster problem-solving abilities and creativity. In their study, Miao, Du, Dong, Liu, & Wang (2020) propose a data-collecting model specifically designed for 3D printing classes. This model aims to evaluate students' spatial thinking and engineering design skills. Lu et al. (2022) provide evidence for the beneficial impact of PBL, focusing on the STEAM curriculum on children with learning difficulties. They observe enhancements in creativity and academic

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

accomplishments. Liston et al. (2022) investigate the incorporation of data science and the IoT into STEAM education in Ireland. They aim to encourage transdisciplinary learning by using advanced technologies.

Facilitating creativity and problem-solving skills through STEAM education needs a blend of educational approaches, digital technologies, and new projects. Love et al. (2023) study merging science and poetry in teacher training, finding that online and face-to-face formats greatly enhance confidence in teaching science. Vasylykiv Ivan (2024) stress the importance of digital technologies in boosting critical thinking and creativity among prospective primary school educators. Lage-Gómez & Ros (2024) apply graph theory to study the connection between cognitive and conative components of creativity in STEAM initiatives. Arabit-Garcia et al. (2023) highlight the efficiency of accessible instructional materials and active techniques in encouraging creativity and problem-solving abilities in STEM education. Phonnong & Keeratichamroen (2023) analyze the problems and gains from remote STEAM education during the COVID-19 epidemic in an underprivileged Thai primary school, noting its favorable impact on students' creative and problem-solving capacities. Aydin (2020) lists fundamental conditions for elementary school instructors before implementing STEM education, highlighting the necessity of integrated, problem-based learning techniques.

Several studies underline the impact of new strategies in STEAM education across varied locations and groups. Zviel-Girshin et al. (2020) study robots to increase technological thinking and essential 21st-century abilities in early childhood education, underlining the need for early technological involvement. Bautista (2021) presents empirical data on the credibility and effectiveness of STEAM education, highlighting the necessity for comprehensive research to support its wider implementation. Robb (2024) recognizes a requirement for increased training and professional development in art instruction among primary school teachers in Scotland to improve educational performance. Martinez-Jimenez et al. (2022) promote employing urban areas as instructional instruments through problem-posing and Math Trails, illustrating the benefits of contextual learning in boosting mathematical comprehension. Schut et al. (2022) stress the value of guided feedback in developing creative thinking among young novice designers. Chen (2023) analyses the advantages of game-based learning, which is applied through university-school cooperation, in encouraging innovative thinking. These examples highlight how STEAM education may effectively adapt to multiple contexts and populations, increasing educational methods across various settings.

Conclusion

Ultimately, the latest study on STEAM education showcases a groundbreaking capacity to enhance teaching and learning processes through innovative approaches and practices. Research highlights the importance of incorporating STEAM projects into national curricula and implementing strategic techniques such as "forward" and "backward" curriculum mapping to identify opportunities for progress. The hands-on, student-centered learning style of STEAM education significantly enhances creativity and passion compared to traditional techniques. Utilizing instructional approaches like the 5E method and PBL improves problem-solving abilities and fosters creativity, particularly in children with learning difficulties. The incorporation of digital tools and modern information technology in STEAM education enhances critical thinking and creativity, providing benefits for both teachers and students. Furthermore, the use of innovative teaching techniques, such as the integration of science and poetry or the utilization of urban landscapes for contextual learning, showcases the adaptable

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

nature of STEAM education in various educational contexts. The impact of STEAM education is seen in diverse environments and educational stages, spanning from early childhood to primary and vocational school.

Incorporating robots, data science, and the IoT into STEAM courses enhances technological comprehension and fosters the cultivation of 21st-century proficiencies. Furthermore, it is stressed that there is a need for improved training and possibilities for professional development for educators to guarantee that they have the essential abilities and expertise to effectively incorporate STEAM instruction. These studies illustrate the extensive benefits of STEAM education in enhancing creativity, problem-solving abilities, and overall learning experiences. They advocate for the extensive implementation and customization of STEAM education in various educational settings.

The findings reveal some valuable and actionable insights for educators. The deliberate integration of artistic aspects into STEM curricula can greatly augment students' inventiveness. Implementing PBL and IBL methodologies is essential for creating dynamic and engaging learning environments that promote students' curiosity and problem-solving skills. Promoting interdisciplinary collaboration enhances teamwork across several subject areas, hence enhancing critical thinking and the ability to integrate concepts from other fields. In addition, via the use of advanced technology like VR and AR, it is feasible to create immersive STEAM learning experiences that offer a more tangible and captivating comprehension of abstract subjects, hence improving the overall educational experience.

Acknowledgements
Appreciation to the School of Educational Studies, Universiti Sains Malaysia and all who are directly or indirectly involved in the making of this writing.

References

Ahmed Dool, M., Akhtar, N., & Khan, N. (2021). Inquiry-Based Learning Practices for Science Teaching in Elementary Grades: A Literature Review of the Asian Countries. *Global Educational Studies Review*, *VI*(IV), 54–63. https://doi.org/10.31703/gesr.2021(VI-IV).06

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics*, *12*(18), 3953. https://doi.org/10.3390/electronics12183953

Anisimova, T. I., Sabirova, F. M., & Shatunova, O. V. (2020). Formation of Design and Research Competencies in Future Teachers in the Framework of STEAM Education. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(02), 204. https://doi.org/10.3991/ijet.v15i02.11537

Arabit-Garcia, J., Prendes-Espinosa, M. P., & Serrano, J. L. (2023). Open Educational Resources and active methodologies for STEM teaching in Primary Education. *REVISTA LATINOAMERICANA DE TECNOLOGIA EDUCATIVA-RELATEC*, *22*(1), 89–106. https://doi.org/10.17398/1695-288X.22.1.89

Aydin, G. (2020). Prerequisites for Elementary School Teachers before Practicing STEM Education with Students: A Case Study. *EURASIAN JOURNAL OF EDUCATIONAL RESEARCH*, (88), 1–39. https://doi.org/10.14689/ejer.2020.88.1

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Bautista, A. (2021). STEAM Education: Contributing Evidence of Validity and Effectiveness. *JOURNAL FOR THE STUDY OF EDUCATION AND DEVELOPMENT*, *44*(4), 755–768. https://doi.org/10.1080/02103702.2021.1926678

Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, *53*(11), 2919–2955. https://doi.org/10.1080/0020739X.2021.1922943

Breda, A., Garcia, V., & Santos, N. (2023). Teachers' Perceptions of STEAM Education. *International Journal of Technology in Education*, *6*(4), 700–719. https://doi.org/10.46328/ijte.563

Chang, C.-Y., Du, Z., Kuo, H.-C., & Chang, C.-C. (2023). Investigating the Impact of Design Thinking-Based STEAM PBL on Students' Creativity and Computational Thinking. *IEEE Transactions on Education*, *66*(6), 673–681. https://doi.org/10.1109/TE.2023.3297221

Chen, X. (2023). University-school interaction in implementing game-based learning for creative thinking development. *EDUCATION AND INFORMATION TECHNOLOGIES*, *28*(2), 1833–1848. https://doi.org/10.1007/s10639-022-11208-z

Cheng, L., Wang, M., Chen, Y., Niu, W., Hong, M., & Zhu, Y. (2022). Design My Music Instrument: A Project-Based Science, Technology, Engineering, Arts, and Mathematics Program on The Development of Creativity. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.763948

Conradty, C., Sotiriou, S. A., & Bogner, F. X. (2020). How Creativity in STEAM Modules Intervenes with Self-Efficacy and Motivation. *Education Sciences*, *10*(3), 70. https://doi.org/10.3390/educsci10030070

Dewi, D. K., Ardhana, W., Irtadji, Chusniyah, T., & Sulianti, A. (2021). Inquiry-Based Learning Implementation to Improve Critical Thinking of Prospective Teachers. *International Journal of Information and Education Technology*, *11*(12), 638–645. https://doi.org/10.18178/ijiet.2021.11.12.1575

Gupta, C. (2022). The Impact and Measurement of Today's Learning Technologies in Teaching Software Engineering Course Using Design-Based Learning and Project-Based Learning. *IEEE Transactions on Education*, *65*(4), 703–712. https://doi.org/10.1109/TE.2022.3169532

Hebebci, M. T., & Usta, E. (2022). The Effects of Integrated STEM Education Practices on Problem Solving Skills, Scientific Creativity, and Critical Thinking Dispositions. *Participatory Educational Research*, *9*(6), 358–379. https://doi.org/10.17275/per.22.143.9.6

Hoi, H. T. (2021). Applying STEAM Teaching Method to Primary Schools to Improve the Quality of Teaching and Learning for Children. *International Journal of Early Childhood Special Education*, *13*(2), 1051–1055. https://doi.org/10.9756/INT-JECSE/V13I2.211149

Ibrahim Mohammed Elfeky, A., Mohammed Alharbi, S., & Sultan Abdul Hameed Ahmed, E. (2022). The Effect Of Project-Based Learning In Enhancing Creativity And Skills Of Arts Among Kindergarten Student Teachers. In *Journal of Positive School Psychology* (Vol. 2022). Retrieved from http://journalppw.com

Isdianti, M., Nasrudin, H., & Erman, E. (2021). The effectiveness of STEM based inquiry learning packages to improving students' critical thinking skill. *Journal for the*

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Education of Gifted Young Scientists, *9*(3), 223–232. https://doi.org/10.17478/jegys.832239

Lage-Gómez, C., & Ros, G. (2024). On the interrelationships between diverse creativities in primary education STEAM projects. *Thinking Skills and Creativity*, *51*. https://doi.org/10.1016/j.tsc.2023.101456

Li, J., Luo, H., Zhao, L., Zhu, M., Ma, L., & Liao, X. (2022). Promoting STEAM Education in Primary School through Cooperative Teaching: A Design-Based Research Study. *Sustainability*, *14*(16), 10333. https://doi.org/10.3390/su141610333

Liston, M., Morrin, A. M., Furlong, T., & Griffin, L. (2022). Integrating Data Science and the Internet of Things Into Science, Technology, Engineering, Arts, and Mathematics Education Through the Use of New and Emerging Technologies. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.757866

Love, T. S., Napoli, M., & Lee, D. (2023). Examining pre-service elementary educators' perceptions of teaching science when integrated with poetry. *School Science and Mathematics*, *123*(2). https://doi.org/10.1111/ssm.12569

Lu, S.-Y., Wu, C.-L., & Huang, Y.-M. (2022). Evaluation of Disabled STEAM-Students' Education Learning Outcomes and Creativity under the UN Sustainable Development Goal: Project-Based Learning Oriented STEAM Curriculum with Micro:bit. *Sustainability (Switzerland)*, *14*(2). https://doi.org/10.3390/su14020679

Martinez-Jimenez, E., Nolla de Celis, A., & Fernandez-Ahumada, E. (2022). The City as a Tool for STEAM Education: Problem-Posing in the Context of Math Trails. *MATHEMATICS*, *10*(16). https://doi.org/10.3390/math10162995

Miao, Z., Du, J., Dong, F., Liu, Y., & Wang, X. (2020). Identifying technology evolution pathways using topic variation detection based on patent data: A case study of 3D printing. *Futures*, *118*. https://doi.org/10.1016/j.futures.2020.102530

Montes, N., Zapatera, A., Ruiz, F., Zuccato, L., Rainero, S., Zanetti, A., … Marathefti, M. (2023). A Novel Methodology to Develop STEAM Projects According to National Curricula. *Education Sciences*, *13*(2). https://doi.org/10.3390/educsci13020169

Nguyen Thi Thu, H., Tran Ngoc, B., & Nguyen, T.-B. (2023). Applying the Engage, Explore, Explain, Elaborate, and Evaluate Procedure in STEAM Education for Primary Students: A Sample with the Topic "My Green Garden" †. *Engineering Proceedings*, *55*(1). https://doi.org/10.3390/engproc2023055061

Okwara, V. U., & Henrik Pretorius, J. P. (2023). The STEAM vs STEM Educational Approach: The Significance of the Application of the Arts in Science Teaching for Learners' Attitudes Change. *Journal of Culture and Values in Education*, *6*(2), 18–33. https://doi.org/10.46303/jcve.2023.6

Ozkan, G., & Umdu Topsakal, U. (2021). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research in Science and Technological Education*, *39*(4). https://doi.org/10.1080/02635143.2020.1769586

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery*, *88*. https://doi.org/10.1016/j.ijsu.2021.105906

Phonnong, I., & Keeratichamroen, W. (2023). Perspectives on STEAM Education during the COVID-19 Pandemic at an Underprivileged Elementary School in Thailand. *International Journal of Science, Mathematics and Technology Learning*, *30*(2), 15–32. https://doi.org/10.18848/2327-7971/CGP/v30i02/15-32

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 22 (September 2024) PP. 319-335
DOI: 10.35631/IJMOE.622024

Robb, A. (2024). Teacher's Views of Art Education in Primary Schools in Scotland. *International Journal of Art and Design Education*, *43*(2), 178–189. https://doi.org/10.1111/jade.12486

Rodrigues-Silva, J., & Alsina, Á. (2023). STEM/STEAM in Early Childhood Education for Sustainability (ECEfS): A Systematic Review. *Sustainability*, *15*(4), 3721. https://doi.org/10.3390/su15043721

Rukayah, Daryanto, J., Atmojo, I. R. W., Ardiansyah, R., Saputri, D. Y., & Salimi, M. (2022). Augmented Reality Media Development in STEAM Learning in Elementary Schools. *Ingénierie Des Systèmes d Information*, *27*(3), 463–471. https://doi.org/10.18280/isi.270313

Schut, A., van Mechelen, M., Klapwijk, R. M., Gielen, M., & de Vries, M. J. (2022). Towards constructive design feedback dialogues: guiding peer and client feedback to stimulate children's creative thinking. *International Journal of Technology and Design Education*, *32*(1), 99–127. https://doi.org/10.1007/s10798-020-09612-y

Truong Thi, D., & Dinh Nguyen Trang, T. (2022). Some solutions to enhance the quality of inclusive education for children with disabilities through STEAM education application. *Journal of Science Educational Science*, *67*(5A), 227–235. https://doi.org/10.18173/2354-1075.2022-0137

Tytler, R. (2020). STEM education for the twenty-first century. *Integrated Approaches to STEM Education: An International Perspective*, 21–43.

Vasylykiv Ivan, Z. O. I. S. K. N. L. S. (2024). *View of Modern Information Technologies in the Professional Education of Future Primary School Teachers*.

Velarde-Camaqui, D., Celaya-Ramírez, R., Contreras-Fuentes, Y., & Sanabria-Z, J. (2024). Enhancing STEAM education through augmented reality: the EduAR open platform experience. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1391803

Warsah, I., Morganna, R., Uyun, M., Hamengkubuwono, H., & Afandi, M. (2021). The Impact of Collaborative Learning on Learners' Critical Thinking Skills. *International Journal of Instruction*, *14*(2), 443–460. https://doi.org/10.29333/iji.2021.14225a

Ye, P., & Xu, X. (2023). A case study of interdisciplinary thematic learning curriculum to cultivate "4C skills." *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1080811

Yin, X. (2021). Integrating design thinking into STEAM education: The design of STEAM education platform and course based on creativity elements. *LearnxDesign 2021: Engaging with Challenges in Design Education*. Design Research Society. https://doi.org/10.21606/drs_lxd2021.02.267

Zviel-Girshin, R., Luria, A., & Shaham, C. (2020). Robotics as a Tool to Enhance Technological Thinking in Early Childhood. *Journal of Science Education and Technology*, *29*(2), 294–302. https://doi.org/10.1007/s10956-020-09815-x