

INTEGRATION OF STEAM-BASED MEDIA AND PROJECT-BASED LEARNING IN MATHEMATICS LEARNING

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Abstract

Mathematics learning today demands innovations that can develop students' higher-order thinking skills, creativity, and numeracy literacy. The integration of the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach with the Project-Based Learning (PjBL) model is one alternative that is believed to be effective in providing more contextual and meaningful learning. This study aims to analyze findings related to the effectiveness of integrating STEAM-based media and PjBL in mathematics learning through a literature review. The method used is a literature review by examining fifteen relevant articles containing empirical data regarding the application of STEAM, STEAM-based digital media, and project-based learning steps at various levels of education. The analysis was carried out by identifying patterns, similarities, and differences in the findings from each article. The results of the study indicate that the integration of STEAM and PjBL media can significantly improve critical thinking skills, creativity, numeracy literacy, and student learning outcomes. In addition, this approach also contributes to strengthening student character, such as cooperation, communication, and responsibility. Overall, the synthesis of research findings confirms that STEAM-PjBL-based mathematics learning can be an effective strategy in improving the quality of learning and meeting the demands of 21st century competencies.

Keywords: STEAM, Project-Based Learning, Learning media, Numeracy literacy

Abstrak

Pembelajaran matematika saat ini menuntut inovasi yang mampu mengembangkan kemampuan berpikir tingkat tinggi, kreativitas, dan literasi numerasi siswa. Integrasi pendekatan Science, Technology, Engineering, Arts, and Mathematics (STEAM) dengan model Project-Based Learning (PjBL) merupakan salah satu alternatif yang diyakini efektif untuk menghadirkan pembelajaran yang lebih kontekstual dan bermakna. Penelitian ini bertujuan untuk menganalisis temuan-temuan terkait efektivitas integrasi media berbasis STEAM dan PjBL dalam pembelajaran matematika melalui kajian literatur. Metode yang digunakan adalah literature review dengan menelaah lima belas artikel yang relevan dan memuat data empiris mengenai penerapan STEAM, media digital berbasis STEAM, serta langkah pembelajaran berbasis proyek pada berbagai jenjang pendidikan. Analisis dilakukan dengan mengidentifikasi pola, persamaan, dan perbedaan temuan dari setiap artikel. Hasil kajian menunjukkan bahwa integrasi media STEAM dan PjBL mampu meningkatkan kemampuan berpikir kritis, kreativitas, literasi numerasi, serta hasil belajar siswa secara signifikan. Selain itu, pendekatan ini juga berkontribusi terhadap penguatan karakter siswa, seperti kerja sama, komunikasi, dan tanggung jawab. Secara keseluruhan, sintesis temuan penelitian menegaskan bahwa pembelajaran matematika berbasis STEAM-PjBL dapat menjadi strategi yang efektif dalam meningkatkan kualitas pembelajaran serta memenuhi tuntutan kompetensi abad ke-21

Kata kunci: STEAM, Project-Based Learning, Media pembelajaran, Literasi numerasi

INTRODUCTION

The development of 21st century education demands learning innovations that integrate critical thinking, creativity, collaboration, and technological literacy. In mathematics education, this demand is particularly urgent because mathematics functions not only as a procedural discipline but also as a means to develop higher order thinking and

problem solving skills. However, mathematics learning in classrooms is still often dominated by conventional, teacher centered approaches that limit students' opportunities to actively construct knowledge through meaningful experiences, resulting in low student engagement and underdeveloped numeracy literacy (Izzah, 2024; Lince et al., 2023).

To address these challenges, the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach has emerged as an interdisciplinary framework that integrates multiple domains to promote creativity, critical thinking, and real world problem solving. In mathematics learning, STEAM encourages exploration, design, experimentation, and the use of technology, making learning more contextual and authentic (Izzah, 2024). In parallel, Project Based Learning (PjBL) has been recognized as an instructional model that engages students in solving real life problems through collaborative projects, enabling deeper conceptual understanding while fostering essential 21st century skills such as communication and teamwork (Diana & Saputri, 2021).

Several studies have demonstrated the effectiveness of integrating STEAM and PjBL in mathematics learning. Diana and Saputri (2021) found that the PjBL-STEAM model significantly improved students' critical thinking skills and emotional intelligence in numeracy based tasks. Similarly, Almarwah et al. (2025) reported a high N-gain score, indicating a substantial improvement in students' critical thinking skills after implementing STEAM-based PjBL. In terms of creativity, Ayuningsih et al. (2022) showed that STEAM-PjBL learning resulted in very high creativity indicators, including elaboration, flexibility, and originality. Furthermore, STEAM-based digital learning media, such as e-modules and digital textbooks, have been shown to be valid, practical, and effective in supporting mathematics learning and increasing student motivation (Jayanti et al., 2022; Aini et al., 2023).

Beyond cognitive outcomes, previous studies also highlight the contribution of STEAM-PjBL integration to students' character development. Supianti et al. (2025) emphasized that STEAM-PjBL learning fosters collaboration, communication, and responsibility, while Lince et al. (2023) reported positive effects on students' interest in mathematics and numeracy skills at the elementary level. These findings indicate that the STEAM-PjBL approach supports holistic learning outcomes, encompassing cognitive, affective, and character dimensions.

Despite these promising findings, existing research tends to focus on specific implementations, particular learning outcomes, or single educational levels, resulting in fragmented insights into the integration of STEAM-based media and Project Based Learning in mathematics education. Moreover, many studies examine either the learning model or the learning media separately, while comprehensive literature reviews that systematically synthesize empirical evidence on the combined effectiveness of STEAM-based media and PjBL in mathematics learning remain limited. This indicates a research gap in providing an integrated and systematic overview of how STEAM-PjBL contributes to mathematics learning, particularly in developing numeracy literacy and 21st century skills.

Therefore, this study aims to address this gap by conducting a literature review that analyzes and synthesizes research findings on the integration of STEAM-based learning media and Project Based Learning in mathematics education. The results of this study are expected to provide a clearer conceptual and empirical understanding of the effectiveness, implementation patterns, and educational contributions of STEAM-PjBL as an innovative strategy to improve the quality of mathematics learning in the context of 21st century education.

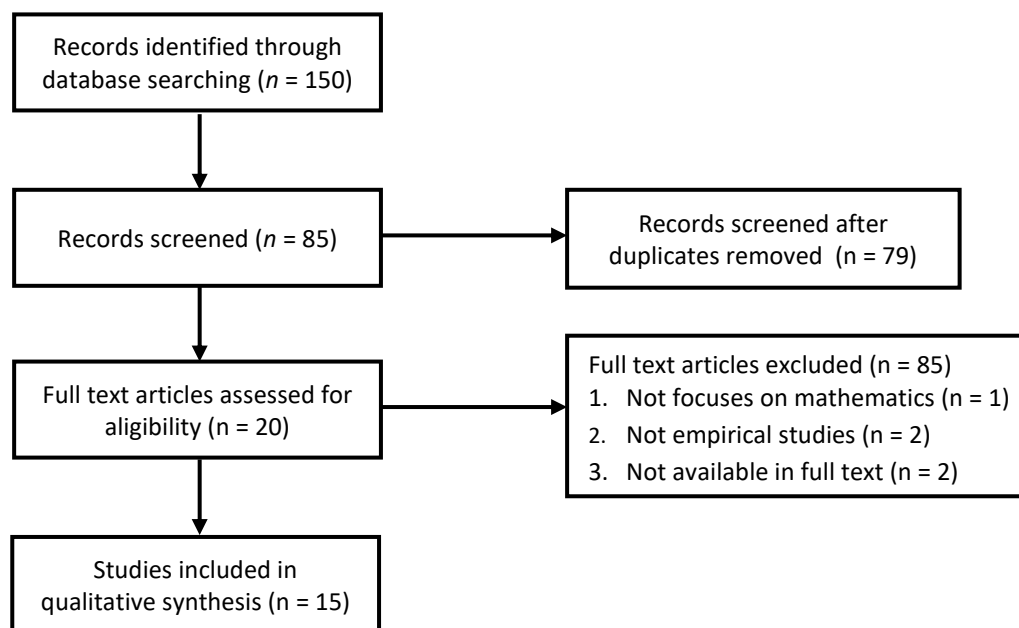
METHODS

This study employed a literature review design to systematically collect, analyze, and synthesize empirical research related to the integration of STEAM-based learning media and Project-Based Learning (PjBL) in mathematics education. The review focused on identifying patterns of implementation, effectiveness, and educational outcomes associated with STEAM–PjBL integration.

The literature search was conducted using three academic databases: Google Scholar, DOAJ (Directory of Open Access Journals), and Garuda. The search covered publications from 2020 to 2025 to ensure the relevance and recency of the findings. Keywords used in various combinations included: "STEAM learning", "Project Based Learning", "STEAM-PjBL", "mathematics learning media", "numeracy literacy", and "mathematics education". The search process aimed to capture peer-reviewed journal articles reporting empirical data on STEAM, PjBL, or their integration in mathematics learning.

The article selection process followed the PRISMA (Preferred reporting items for systematic reviews and meta analyses) guidelines to ensure transparency and

methodological rigor. Initially, a total of articles were identified through database searching. After removing duplicate records, the remaining articles were screened based on their titles and abstracts to assess relevance to the research focus. Articles that did not address mathematics learning, STEAM, or PjBL were excluded at this stage. The full texts of the remaining articles were then assessed for eligibility based on predefined inclusion and exclusion criteria. Finally, fifteen articles that met all criteria were included in the qualitative synthesis.



To ensure the quality and relevance of the reviewed studies, explicit inclusion and exclusion criteria were applied. The included articles were empirical research studies published between 2020 and 2025 that focused on mathematics learning at any educational level and involved the application of the STEAM approach, Project Based Learning, or their integration. Furthermore, only studies that reported measurable learning outcomes such as learning achievement, critical thinking skills, creativity, numeracy literacy, or character development and were available in full text form in peer reviewed journals were considered eligible for inclusion.

Conversely, articles were excluded if they were conceptual papers, opinion articles, or literature reviews without empirical data, as well as studies that were not related to mathematics education. Articles focusing solely on STEM or STEAM without a clear instructional model or learning context were also excluded. In addition, duplicate

publications identified across databases and studies with incomplete methodological descriptions or inaccessible full texts were removed from the analysis.

A brief quality appraisal was conducted to assess the methodological soundness of the selected studies. Each article was evaluated based on three main aspects: (1) clarity of research objectives, (2) appropriateness of research design and data collection methods, and (3) clarity and validity of reported findings. The appraisal showed that most studies employed appropriate research designs, such as quasi-experimental, development research, or classroom action research, and reported clear outcomes supported by data analysis. Overall, the selected articles demonstrated adequate methodological quality and were deemed suitable for inclusion in the synthesis.

Data extraction was carried out by identifying key information from each selected article, including author(s), year of publication, research objectives, educational level, type of STEAM-based media or PjBL implementation, research methods, and main findings. The extracted data were then organized thematically into categories such as critical thinking, creativity, numeracy literacy, learning outcomes, and character development. A descriptive qualitative analysis was conducted to compare findings across studies, identify recurring patterns, and synthesize the overall effectiveness of STEAM-PjBL integration in mathematics learning.

RESULTS AND DISCUSSION

The results and literature searches conducted through academic databases such as Google Scholar, DOAJ (Directory of Open Access Journals), and Garuda regarding the integration of steam-based media and project-based learning in mathematics learning over the past five years (2020-2025) are as follows:

Table 1. Research Literature

Research title	Author/Year	Research result
Model Project Based Learning Terintegrasi Steam Terhadap Kecerdasan Emosional Dan Kemampuan Berpikir Kritis Siswa	Hafsah Adha Diana & Veni Saputri (2021)	Hasil penelitian menunjukkan bahwa: (1) Peningkatan kemampuan berpikir kritis berbasis numerasi siswa dengan kemampuan awal matematika tinggi yang mendapat perlakuan model PjBL-STEAM lebih tinggi dibandingkan siswa yang mendapat perlakuan model pembelajaran langsung, (2) Kecerdasan emosional siswa

Berbasis Soal Numerasi			yang mendapat perlakuan model PjBL-STEAM lebih tinggi dibandingkan dengan siswa yang mendapat perlakuan model pembelajaran langsung, (3) Penerapan model PjBL-STEAM membuat siswa mampu membangun kecakapan dalam dunia nyata, seperti bekerjasama, mengambil keputusan, inisiatif, komunikasi, pemecahan masalah dan manajemen diri sehingga dapat meningkatkan kemampuan berpikir kritis siswa berbasis soal numerasi (4) Peningkatan kemampuan berpikir kritis siswa yang mendapat perlakuan model PjBL secara keseluruhan lebih tinggi dibandingkan dengan siswa yang mendapat perlakuan model pembelajaran langsung.
Pengembangan Emometri (E-Modul Trigonometri) Dengan Project Based Learning Berbasis STEAM	Arum Dwi Jayanti, Tri Nova & Hasti Yunianta (2022)		Berdasarkan uji pakar media dan uji pakar materi, media dinyatakan valid dengan rata-rata 89,32% yang berkategori sangat baik. Media pembelajaran dinyatakan praktis berdasarkan uji kepraktisan oleh validator dengan rata-rata 90% yang berkategori sangat baik. Emometri dinyatakan efektif berdasarkan hasil Uji Wilcoxon Pretest dan Posttest peserta didik. Emometri terbukti valid, praktis, dan efektif untuk digunakan dalam pembelajaran pada materi trigonometri.
Implementasi STEAM Pada Pembelajaran Matematika Dalam Menunjang Keterampilan Abad 21	Nur Izzah Azzahra (2024)		Implementasi STEAM pada pembelajaran matematika ini mampu untuk mendukung siswa mencapai kompetensi abad 21. Penerapan STEAM ini juga tidak sulit dikarenakan era Pendidikan saat ini memang sudah menuju era revolusi industri 4.0. Sehingga dalam penerapannya pada kegiatan pembelajaran tentu sarana dan prasarana yang dibutuhkan sudah memadai dan menunjang proses pembelajaran. Oleh karena itu, sangat direkomendasikan kepada pendidik untuk menerapkan pembelajaran berbasis STEAM sebagai salah satu cara untuk menunjang kompetensi siswa abad 21.
Efektivitas Model Pjbl Berbasis STEAM (Science, Technology, Engineering, Art, And	Sofiah Almarwah, Andinisa Rahmani, &		Hasil analisis data memperlihatkan adanya kenaikan nilai rata-rata dari pretest ke posttest sebesar 48,5. Uji N-Gain menunjukkan nilai sebesar 0,71 dengan kategori tinggi yang berarti pembelajaran PjBL-STEAM ini mampu dalam

Mathematics) Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa	Shinta Purnamasari (2025)	meningkatkan keterampilan berpikir kritis siswa, dengan hasil indikator memberikan penjelasan sederhana mengalami peningkatan tertinggi dengan nilai N-Gain 0,71, dan indikator menyimpulkan mengalami peningkatan paling rendah dengan nilai N-Gain 0,67. Temuan ini mendukung penggunaan model PjBL-STEAM sebagai pendekatan inovatif untuk terciptanya pengalaman belajar yang relevan dengan kehidupan sehari-hari.
Pengembangan Buku Ajar Digital Berbasis STEAM-PjBL Pada Mata Kuliah Metode Numerik	Septi Dariyatul Aini, Chairul fajar Tafrilyanto, Agus Subaidi & Laili Amalia (2023)	Hasil dari penelitian dan pengembangan ini yaitu buku ajar digital berbasis STEAM-PjBL terbukti dapat membantu dosen mengelola pembelajaran dan memenuhi ketuntasan belajar mahasiswa, serta membangkitkan minat belajar mahasiswa pada perkuliahan metode numerik.
Implementasi Pendekatan STEAM Berbasis PjBL Dalam Meningkatkan Hasil Pembelajaran Matematika	Dewi Sartika, Dewi Silviana, & Syarifuddin (2023)	Hasil penelitian ini yaitu dalam pelaksanaan penelitian ini dilakukan selama 2 siklus, setiap siklus mengalami peningkatan yang signifikan baik dari segi proses keterlibatan siswa dalam belajar maupun dari segi hasil belajar. Kesimpulan dari penelitian ini yaitu implementasi pendekatan STEAM berbasis PjBL dapat meningkatkan proses dan hasil belajar siswa pada mata pelajaran matematika
Penerapan Model Pembelajaran Project Based Learning Berbasis STEAM Pada Pokok Pembahasan Aritmatika Sosial	Veiren Gahung, Derel F. Kaunang & Marvel G. Maukar (2024)	Hasil penelitian ini memberikan bukti empiris yang mendukung teori bahwa model pembelajaran PjBL berbasis STEAM lebih efektif dalam meningkatkan hasil belajar siswa dibandingkan dengan model pembelajaran konvensional. Penerapan model PjBL berbasis STEAM tidak hanya meningkatkan hasil belajar siswa dalam materi aritmatika sosial tetapi juga mempersiapkan mereka dengan keterampilan yang relevan untuk menghadapi tantangan masa depan.
Evaluation And Effects Of STEAM-PjBL On Mathematics Interest And Numeracy Skills	Ranak Lince, Rustam, & Priska E.L Ero (2023)	This finding suggests that the implementation of a project- based STEAM approach has a positive and significant effect on students' interest in learning mathematics and their numeracy skills.Observations and

On Elementary School		interviews further corroborate the effectiveness of this approach in improving students' abilities. However, the study also identifies certain shortcomings in its application, underscoring the need for careful preparation to ensure optimal outcomes. In conclusion, this study provides valuable insights into the potential of the STEAM approach, combined with project-based learning, to enhance elementary school students' engagement and performance in mathematics. It also highlights the importance of continuous evaluation and refinement of teaching strategies to meet the evolving needs of 21st-century learners
Meningkatkan Kemampuan Komputasi Dengan Model Pembelajaran Berbasis STEAM-PjBL	M. Nazali Ramadhon Hafid, Abdurrahman, & Dwi Yulianti (2025)	Hasil penelitian ini menunjukkan bahwa penggunaan LKPD berbasis STEAM-PjBL berpengaruh positif dalam meningkatkan keterampilan berpikir kreatif. Siswa menjadi lebih aktif dalam belajar, memenuhi seluruh indikator keterampilan berpikir kreatif seperti abstraksi, dekomposisi, pengenalan pola, dan algoritma.
STEAM Approach In Project-Based Learning To Develop Mathematical Literacy And Students' Character	In In Supianti, Poppy Yaniawati, Ebenezer Bonyah, Astri Widiastuti Hasbiah, & Nisrina Rozalini (2025)	The study results revealed that students' mathematical literacy significantly improved after participating in STEAM-PjBL-based learning. Additionally, STEAM-PjBL fosters the development of students' character traits, including teamwork, communication, and responsibility, highlighting its potential to support holistic educational outcomes. These findings indicate that integrating STEAM principles with PjBL enhances academic performance and cultivates critical 21st-century skills.
Pembelajaran Matematika Polinomial Berbasis STEAM - PjBL Menumbuhkan Kreativitas Peserta Didik	Fitri Ayuningsih, Siti Malikhah, Muh Rifki Nugroho, Winarti, Budi Murtiyasa, & Sumardi	Hasil penelitian ini terhadap indikator kreativitas adalah fleksibilitas sebesar 96%, Originalitas sebesar 96%, Elaborasi sebesar 100 %, fluency sebesar 92%. Dengan presentase tertinggi diperoleh pada indikator elaborasi 100%, dan presentase terendah pada indikator fluency sebesar 92 % dengan rata rata sebesar 96% (sangat baik). Penelitian ini menunjukkan hasil belajar dengan kriteria baik yaitu nilai rata rata kelas 86 melebihi KKM yaitu 75

(2022)		
Implementation Of The STEAM-GeoGebra Integrated PjBL Model To Improve Student's Critical Thinking Skills	Nurusy Syahrotir Rohma, Wahyuni Suryaningtyas, & Lis Holisin	The study results show that students' critical thinking skills have increased, this is indicated by the large N-gain value of 0.42 in the medium category and the students' responses are in the good category with an average of 75. Furthermore, the results of this study indicate that there is an increase in critical thinking skills through the application of the STEM-GeoGebra integration PjBL model.
Pengaruh PjBL-STEAM Terhadap Kemampuan Memecahkan Masalah Dan Kreativitas Anak Usia 5-6 Tahun	Atta Fatimatuz Zahro, Habib Mughoyat Zaulhaq, Ruqoyyah Fitri, & Nurul Khotimah	Hasil penelitian menunjukkan peningkatan signifikan dalam kemampuan memecahkan masalah dan kreativitas pada kelompok eksperimen setelah intervensi PjBL-STEAM. Anak-anak dalam kelompok eksperimen menunjukkan peningkatan yang lebih besar dalam kemampuan mengamati, mengumpulkan informasi, mengolah informasi, dan mengkomunikasikan hasil karyanya dibandingkan dengan kelompok kontrol. Analisis statistik menunjukkan perbedaan yang signifikan antara kedua kelompok dalam hal peningkatan kemampuan pemecahan masalah dan kreativitas. Berdasarkan penelitian ini menunjukkan pentingnya pendekatan PjBL-STEAM dalam meningkatkan keterlibatan aktif anak dalam pembelajaran, memperluas keterampilan kognitifnya dan mendorong kreativitas melalui eksplorasi proyek kolaboratif
Perangkat Pembelajaran Pendekatan STEAM-PjBL Pada Tema 2 Selalu Berhemat Energi	Ni Putu Linda Krisna Dewi, I Gede Astawan, & I made Suarjana	Hasil penelitian yaitu penilaian yang diberikan oleh para ahli rata-rata mendapatkan nilai 3,8 sehingga berada pada kategori sangat baik. Hasil penilaian uji coba produk mendapatkan nilai 3,73 sehingga berada pada kategori sangat baik. Jadi perangkat pembelajaran RPP dan LKPD Berpendekatan STEAM-PjBL mendapatkan kualifikasi sangat baik dan layak diterapkan dalam proses pembelajaran dan produk yang dikembangkan dapat digunakan oleh guru dalam proses pembelajaran. Implikasi
Implementation Of The STEAM-Based Project	Muhammad Hayun &	The results obtained showed that the t-test result was 6.990 greater than the t-table of 2.457 with a significance

Based Learning Model In Improving Elementary School Students' Science Problem Solving Ability	Grandi Dwi Setiowati (2023)	level of 0.00 <0.005, which means that there is the influence of the STEAM integrated project based learning learning model on the ability to solve science learning problems in MIS Matlaul Anwar students on the topic of discussion of the human circulatory system. Students who were taught using the project based learning method were better than students who did not use problem based learning in science learning problem solving abilities
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Based on the analysis of various literature studies, it was found that the integration of STEAM-based media and project-based learning in mathematics learning consistently improves various student competencies, including cognitive, affective, and character. The findings from various studies in the table indicate that the STEAM-PjBL approach is able to foster higher-order thinking skills, creativity, numeracy literacy, and collaborative abilities in student learning. This reinforces the view that interdisciplinary learning that combines elements of science, technology, engineering, art, and mathematics provides a more authentic and meaningful learning experience for students.

The implementation of STEAM-PjBL has been shown to have a strong impact on improving critical thinking skills. Several studies, such as those by Diana & Saputri (2021), Almarwah et al. (2025), and Rohmah et al. (2023), show that this model can improve critical thinking skills through numeracy-based problem-solving activities, group discussions, and the use of interactive media such as GeoGebra. Significant increases in N-gain scores and significant differences between pre-test and post-test results indicate that integrating STEAM with projects can facilitate students' in-depth thinking processes. Thus, this approach is highly effective in developing analytical skills, which are at the core of mathematics learning.

In addition to critical thinking, the integration of STEAM-PjBL also contributes significantly to student creativity and innovation. Research by Ayuningsih et al. (2022) showed that creativity indicators such as elaboration, flexibility, and originality reached very high percentages after implementing PjBL-STEAM. A similar finding was demonstrated by Hafid et al. (2025) who found an increase in creative thinking skills through the use of

STEAM-PjBL worksheets, which encouraged students to abstract, recognize patterns, and develop algorithms. These results confirm that combining STEAM-based media with projects can provide space for students to create, explore, and discover new ideas in a mathematical context.

This integration also has a positive impact on students' character and emotional intelligence. Research by Diana & Saputri (2021) showed that the PjBL-STEAM model encourages students to develop skills in collaboration, decision-making, communication, and self-management. These findings are reinforced by research by Supianti et al. (2025), who found that STEAM-PjBL can improve character traits such as responsibility, collaboration, and communication skills. Thus, STEAM-PjBL can not only improve academic aspects, but also shape the essential character of 21st century students.

Regarding learning media, several studies in the table demonstrate that STEAM-PjBL-based media have high validity, practicality, and effectiveness. For example, Jayanti et al. (2022) successfully developed a trigonometry e-module (Emometry) with a "very good" rating based on expert validation and practicality testing. Furthermore, Aini et al. (2023) also demonstrated that a STEAM-PjBL-based digital textbook can help lecturers manage numerical learning and increase student learning interest. This demonstrates the feasibility of using STEAM-PjBL-based digital media to support more interactive and innovative mathematics learning.

Furthermore, the implementation of STEAM-PjBL has a positive impact on learning outcomes and numeracy literacy. Sartika et al. (2023) and Gahung et al. (2024) demonstrated significant improvements in mathematics learning processes and outcomes in each cycle after implementing the model. Furthermore, Lince et al. (2023) also demonstrated an increase in elementary school students' interest and numeracy skills through a STEAM project approach. These findings confirm that STEAM-PjBL integration creates learning that not only enhances conceptual understanding, but also improves overall academic performance.

In general, the findings of this study show a consistent pattern that the integration of STEAM-based media and project-based learning has a positive and significant impact on mathematics learning. This approach not only improves cognitive abilities such as critical thinking, creativity, numeracy literacy, and problem-solving, but also strengthens aspects of

character, student engagement, and the ability to collaborate. Thus, the integration of STEAM-PjBL can be seen as a comprehensive and relevant learning model to meet the demands of modern education. Mathematics learning integrated with STEAM-PjBL can prepare students to face the challenges of the 21st century with balanced academic, technological, and character skills.

CONCLUSION

Based on the synthesis of empirical studies reviewed, it can be concluded that the integration of STEAM-based learning media and Project-Based Learning consistently contributes to the improvement of students' cognitive abilities, particularly critical thinking, creativity, numeracy literacy, and problem-solving skills in mathematics learning. In addition, this integrated approach supports the development of students' character, including collaboration, communication, responsibility, and engagement in learning. The findings indicate that STEAM-PjBL provides a contextual, meaningful, and student-centered learning experience that aligns with the demands of 21st-century education.

The findings of this review have important implications for teachers and curriculum designers. For teachers, the integration of STEAM and Project-Based Learning can serve as an effective instructional strategy to design mathematics learning that is more interactive, contextual, and connected to real-life problems. Teachers are encouraged to utilize STEAM-based media, such as digital modules, worksheets, and interactive tools, to support project activities that promote exploration and higher-order thinking. For curriculum designers, the results highlight the importance of embedding interdisciplinary STEAM principles and project-based approaches into the mathematics curriculum to strengthen numeracy literacy and 21st-century competencies. Curriculum frameworks should therefore provide flexibility and guidance for implementing STEAM-PjBL in classroom practice.

Despite its contributions, this literature review has several limitations. The reviewed studies were limited to articles published between 2020 and 2025 and sourced from selected databases, which may not fully represent all relevant research on STEAM-PjBL in mathematics education. In addition, the included studies varied in research design, educational level, and learning outcomes, making it difficult to conduct a deeper comparative or quantitative analysis of effectiveness. This review also focused on qualitative

synthesis rather than meta-analysis, so the magnitude of the effects of STEAM-PjBL could not be statistically measured.

Based on these limitations, future research is recommended to conduct more systematic reviews or meta-analyses to quantitatively examine the effectiveness of STEAM-PjBL integration in mathematics learning. Further studies could also explore long-term impacts, implementation challenges, and contextual factors that influence the success of STEAM-PjBL across different educational levels and learning environments. Additionally, empirical research focusing on specific components of STEAM-based media and curriculum design would provide deeper insights into how this approach can be optimized to improve mathematics learning outcomes.

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