

AI meets STEAM: A global bibliometric analysis of interdisciplinary education and innovation

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ABSTRACT

This bibliometric analysis explores the intersection of artificial intelligence (AI) and science, technology, engineering, arts, and mathematics (STEAM) education, highlighting the growing interest in the application of intelligent technologies to support interdisciplinary learning and foster creativity. The study analyzed 11,709 publications concerning the evolution of publication output over time, the countries and institutions contributing to the field, the dominant research categories and themes, and the extent to which AI-STEAM research aligns with the United Nations sustainable development goals (SDGs). The findings reveal a marked increase in publication output in this context since 2015, with the United States and China leading global output, supported by contributions from several internationally recognized institutions. Research activity is concentrated in biomedical sciences, engineering, and computer science, while comparatively little attention is devoted to education and the arts. Most studies align with “SDG 3: Good health and well-being,” whereas goals related to educational equity and inclusivity remain underrepresented.

Keywords: artificial intelligence, bibliometric analysis, educational technology, STEAM education, sustainable development goals

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INTRODUCTION

The rapid integration of artificial intelligence (AI) into education has reshaped teaching, learning, and curriculum design, particularly concerning science, technology, engineering, arts, and mathematics (STEAM) education. AI technologies support personalized learning, adaptive assessment, and intelligent tutoring systems, which places AI at the forefront of 21st century educational innovation. At the same time, STEAM emphasizes interdisciplinarity and creativity, preparing students for complex, technology-driven societies. Therefore, the convergence of AI and STEAM holds significant potential for cultivating critical thinking, problem-solving, and digital literacy (Akış, 2024; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023; Tapullima-Mori et al., 2024; Verma et al., 2024). Despite these benefits, the number of comprehensive studies exploring the intersection of AI and STEAM remains limited. Although some works have examined AI in education and global trends in STEAM, few have explored how AI enhances STEAM education in terms of publication patterns, institutional leadership, thematic priorities, and alignment

with the United Nations sustainable development goals (SDGs) (Amanova et al., 2025; Kavitha & Joshith, 2024; Marín-Marín et al., 2021; Su & Yang, 2024).

This study addresses that gap by presenting a bibliometric analysis of AI-STEAM research. It examines publication growth, geographic and institutional distribution, thematic clusters, and links to SDGs, revealing how scholars worldwide conceptualize the field. Earlier works in this context provided useful insights but did not explore longitudinal patterns or institutional contributions. The present analysis identifies trends, highlights research gaps, and points to areas for further inquiry (Pradana et al., 2023; Supriyadi et al., 2023).

Understanding the global landscape of AI-STEAM research is essential for policymakers, educators, and researchers. Findings regarding this field can inform curriculum development, funding priorities, and international collaboration, ensuring that AI integration is inclusive and sustainability-oriented. By linking AI-STEAM research to SDGs—particularly quality education, climate action, and reduced inequalities—the present study underscores the broader societal implications of

technological innovation in education (Donthu et al., 2021; Nan et al., 2025; Pradana et al., 2023; Tapullima-Mori et al., 2024; Verma et al., 2024).

LITERATURE REVIEW

The rapid expansion of STEAM education and AI-driven learning has stimulated a marked increase in academic research, shaping contemporary educational practices and interdisciplinary methodologies. Bibliometric analyses of studies on this topic shed light on global publication trends, institutional contributions, dominant research themes, and emerging challenges. While STEAM research emphasizes creativity, problem-solving, and technological integration, AI in education is primarily associated with adaptive learning, intelligent tutoring, and automation (Kavitha & Joshith, 2024; Pradana et al., 2023; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023).

STEAM Bibliometrics

STEAM education has gained momentum as a transformative approach to interdisciplinary learning. Recent bibliometric analyses highlight its global expansion; the uneven distribution of research publications; and emerging themes such as computational thinking, interdisciplinary learning, and teacher training. Other focal points include the integration of AI, robotics, and gamification in reshaping STEAM methodologies, as well as persistent challenges such as limited teacher preparation, inequalities in resources, and curriculum rigidity (Marín-Marín et al., 2021; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023; Tapullima-Mori et al., 2024).

Since 2015, research output on STEAM education has risen markedly, which reflects its role in promoting skills and growing policy support. Publication activity peaked between 2019 and 2022, driven by educational reforms, technology-enhanced learning, and the acceleration of online and AI-based pedagogies during the COVID-19 pandemic. The United States, China, and South Korea dominate global output and policy initiatives, with leading institutions such as Stanford University, Beijing Normal University, and the Korea National University of Education advancing AI-driven learning and teacher training. Emerging contributions from Latin America, Southeast Asia, and the Middle East demonstrate widening participation, particularly in computational thinking, interdisciplinary pedagogy, and technology integration. Scholars emphasize the importance of scaling research, fostering collaboration, and ensuring equitable access across regions (Amanova et al., 2025; Jantakoon et al., 2024; Rodrigues-Silva & Alsina, 2023; Su & Yang, 2024; Supriyadi et al., 2023; Tapullima-Mori et al., 2024; Zhan et al., 2022).

European nations—notably Spain, the United Kingdom, and Germany—have shown strong engagement in STEAM-related policy and teacher education. Spain has focused on early STEAM integration and digital tools, while the United Kingdom has prioritized teacher training. Latin American,

Southeast Asian, and Middle Eastern countries, including Brazil, Mexico, and Malaysia, are increasingly exploring AI, robotics, and arts-based approaches. However, regional disparities remain pronounced, as underfunded institutions often lack infrastructure, training, and digital resources. Scholars call for stronger collaboration, open-access resources, and equitable policies to reduce these inequalities (Amanova et al., 2025; Jantakoon et al., 2024; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023; Tapullima-Mori et al., 2024; Zhan et al., 2022).

Thematic emphases within STEAM research include computational thinking, interdisciplinary pedagogy, teacher training, and technology-enhanced approaches. Computational thinking has gained particular importance for coding, problem-solving, and AI-driven learning. Interdisciplinary approaches that integrate STEAM with the arts and humanities foster creativity and innovation, while project-based STEAM supports adaptability and real-world problem-solving. Teacher training remains a critical concern, as integrating arts, engineering, and coding into teaching remains a challenge for many educators. Emerging technologies such as AI, robotics, and gamification expand STEAM opportunities through personalized and interactive learning, underscoring the need for continued research into digital innovation and interdisciplinary strategies (Akış, 2024; Amanova et al., 2025; Jantakoon et al., 2024; Marín-Marín et al., 2021; Rodrigues-Silva & Alsina, 2023; Su & Yang, 2024; Supriyadi et al., 2023; Tapullima-Mori et al., 2024).

AI-driven learning platforms have become particularly prominent, with personalized learning, intelligent tutoring, and adaptive feedback shown to improve student outcomes. AI integration also supports data-driven assessments and predictive curriculum adjustments. Alongside this, robotics and coding promote computational thinking, problem-solving, and STEM engagement, typically through hands-on, project-based approaches. Virtual and augmented reality further reshape STEAM education by enabling immersive simulations of complex concepts. Nevertheless, successful implementation requires adequate teacher training, infrastructure development, and equitable access to ensure inclusivity (Akış, 2024; Amanova et al., 2025; Jantakoon et al., 2024; Rodrigues-Silva & Alsina, 2023; Su & Yang, 2024; Supriyadi et al., 2023; Tapullima-Mori et al., 2024).

Despite progress in the use of AI, bibliometric studies reveal persistent barriers to large-scale STEAM adoption. Key challenges include inadequate training for teachers in interdisciplinary methodologies, unequal access to digital infrastructure, and curriculum rigidity rooted in subject-specific models. Wealthier institutions benefit from advanced laboratories and AI-driven learning tools, while underfunded schools struggle to integrate technology. To overcome these challenges, scholars call for structured professional development, greater financial investment, and policy-driven reforms that enable scalable and equitable STEAM education (Akış, 2024; Amanova et al., 2025; Jantakoon et al., 2024; Rodrigues-Silva & Alsina, 2023; Su &

Yang, 2024; Supriyadi et al., 2023; Tapullima-Mori et al., 2024).

AI Bibliometrics

Several bibliometric studies have examined the introduction of AI into education, offering valuable insights into research trends. First, the expansion of AI in education has fueled significant research growth, with many studies emphasizing its global adoption, core applications, and ethical challenges. Second, this field is dominated by a small number of countries and institutions that account for the majority of publications. Third, recurring themes include intelligent tutoring systems, adaptive learning, and AI-driven assessments. Fourth, generative AI tools such as ChatGPT are increasingly reshaping academic support. Finally, issues surrounding data privacy, algorithmic bias, and unequal access highlight the need for responsible AI integration (Afzaal et al., 2024; Kavitha & Joshith, 2024; Lin & Yu, 2023; Pradana et al., 2023; Prahani et al., 2022; Su & Yang, 2024; Verma et al., 2024).

AI-powered learning technologies have expanded rapidly since 2018, driven by growing demand for personalized learning, adaptive tutoring, and automated assessments. The COVID-19 pandemic further accelerated their adoption, with machine learning, tutoring systems, and AI-based grading sustaining remote and hybrid education. China and the United States lead global research output, with institutions such as Tsinghua University, Stanford University, and Massachusetts Institute of Technology at the forefront. Current research emphasizes intelligent tutoring, learning analytics, and ethical governance while highlighting the need for equitable access, transparency, and AI literacy among educators (Afzaal et al., 2024; Kavitha & Joshith, 2024; Lin & Yu, 2023; Nan et al., 2025; Pradana et al., 2023).

At the country level, China, the United States, and the United Kingdom dominate AI-related educational research, particularly in intelligent tutoring, analytics, ethics, and personalized platforms. Emerging economies such as India, Saudi Arabia, and Malaysia are also contributing to the development of AI-enhanced learning models, while Germany and Spain have made notable advances in teacher training and assessment. Nevertheless, low-income institutions continue to face barriers to access, underscoring the need for global collaboration, equitable policies, and targeted investment in AI literacy (Afzaal et al., 2024; Kavitha & Joshith, 2024; Lin & Yu, 2023; Nan et al., 2025; Prahani et al., 2022; Verma et al., 2024).

Key research themes include intelligent tutoring systems, adaptive learning, automated assessment, natural language processing, and AI-powered chatbots. Intelligent tutoring systems adapt instructional content in real time to students' performance and knowledge gaps, improving efficiency in both STEM and language learning. AI-assisted assessments support grading and plagiarism detection but raise concerns about fairness and transparency. Natural language processing underpins applications such as

chatbots, translation tools, and voice-assisted platforms, enhancing multilingual access and self-paced learning. Current research continues to stress ethical governance, learning analytics, and equitable AI deployment (Afzaal et al., 2024; Kavitha & Joshith, 2024; Lin & Yu, 2023; Nan et al., 2025; Prahani et al., 2022; Su & Yang, 2024; Verma et al., 2024).

Generative AI applications and chatbots have transformed personalized learning, student engagement, and automated support systems. Platforms such as ChatGPT, IBM Watson Tutor, and Google's AI assistants are increasingly being applied to content creation, student feedback, and real-time learning support. These tools improve efficiency and assist in managing large student populations, but concerns have been raised about accuracy, ethics, and potential misinformation with their usage. While chatbots streamline advising, enrollment, and tutoring, over-reliance on them may diminish critical thinking, creativity, and learner autonomy. Therefore, there is a need for responsible deployment of AI applications and strong AI literacy (Kavitha & Joshith, 2024; Nan et al., 2025; Pradana et al., 2023; Su & Yang, 2024; Verma et al., 2024).

At the same time, the increasing reliance on AI in education raises critical concerns about privacy, algorithmic bias, and equitable access. AI-powered platforms collecting vast amounts of data creates risks related to security, third-party use, and the misuse of analytics. Algorithmic bias in grading systems, particularly those linked to gender, language, or socioeconomic status, has the potential to reinforce educational inequalities. The digital divide further exacerbates disparities, as underfunded institutions in low-income regions often lack both infrastructure and AI-trained educators. Scholars, therefore, emphasize the urgency of responsible governance, bias mitigation strategies, and inclusive AI policies to ensure that these technologies benefit all learners (Afzaal et al., 2024; Kavitha & Joshith, 2024; Nan et al., 2025; Prahani et al., 2022; Su & Yang, 2024; Verma et al., 2024).

METHODOLOGY

The growth of STEAM education and AI-driven learning has generated extensive academic attention, with bibliometric studies documenting both the expansion of this field and the emergence of new themes and global impacts. However, despite the interdependent research on STEAM education and AI integration, few systematic and data-driven studies have examined their intersection. This gap underscores the need for a bibliometric analysis that investigates how AI contributes to STEAM learning (Kavitha & Joshith, 2024; Supriyadi et al., 2023).

Rationale

Conducting a bibliometric analysis at the intersection of AI and STEAM education provides an opportunity to generate new insights into publication trends, dominant

research regions, and the evolution of AI-enhanced STEAM methodologies. By identifying global research distribution and institutional engagement, this study highlights the regions and universities most actively advancing AI-STEAM education, as well as the emergence of cross-disciplinary collaborations (Jantakoon et al., 2024; Prahani et al., 2022; Su & Yang, 2024; Verma et al., 2024).

Moreover, this analysis explores the core themes structuring AI-STEAM research, including AI-enhanced problem-solving, interdisciplinary pedagogical models, and AI-driven creativity in education. Understanding how AI transforms teaching strategies and facilitates cross-disciplinary approaches will provide critical insight into emerging research directions and technological innovations. Finally, given the increasing integration of sustainability and education, this study also examines the extent to which AI-STEAM research aligns with the United Nations SDGs, situating technological advances within broader social and educational objectives (Afzaal et al., 2024; Lin & Yu, 2023; Nan et al., 2025; Pradana et al., 2023).

The Research Questions

This study aimed to provide a comprehensive bibliometric overview of the integration of AI into STEAM education, focusing on publication rates, global research distribution, thematic priorities, and sustainability concerns. The findings are expected to inform policy development, curriculum design, and equitable AI implementation while also supporting educators, researchers, and policymakers in navigating the evolving landscape of AI-enhanced interdisciplinary learning (Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023).

The analysis was guided by four research questions:

1. What are the publication rates of studies that integrate AI into STEAM education?
2. Which countries, regions, and affiliations contribute most to this body of research?
3. What are the key themes identified in these publications?
4. To what extent do these publications address the United Nations SDGs?

Data were collected from the Web of Science database using the following search command: (All Fields) ["STEAM" OR "STEM" OR "Science, Technology, Engineering, Arts, Mathematics" OR "STEM education" OR "STEAM education"] AND (All Fields) ["AI" OR "Artificial Intelligence"].

The dataset was collected from the Web of Science database using a structured search query, which returned 11,709 records. These included titles, abstracts, keywords, author details, institutional affiliations, and references. After the data were cleaned—which included removing duplicates, standardizing author and institution names, and unifying terminology such as "AI" and "artificial intelligence"—the refined dataset was analyzed to identify annual publication trends, leading countries and

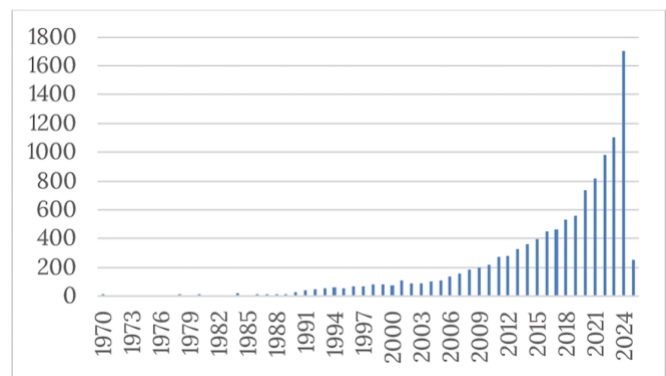


Figure 1. Annual publication trends on AI and STEAM research (1990-2025) (the author-generated visualization based on data exported from Web of Science core collection [Clarivate], coverage up to 2025 [accessed August 2025])

institutions, and thematic clusters. Publications were further coded to assess alignment with the United Nations SDGs, with an emphasis on quality education, equity, and sustainability. This combined quantitative and thematic approach enabled the mapping of global patterns and emerging directions in AI-enhanced STEAM education (Afzaal et al., 2024; Clarivate, 2025; Donthu et al., 2021; Pradana et al., 2023).

FINDINGS

Publication Rates

According to the data from Web of Science (Clarivate, 2025), the number of publications on AI-STEAM research has increased steadily since 2010, with a particularly sharp growth observed after 2018, as shown in **Figure 1**. The dataset included 11,709 publications, the majority of which were published in the last five years. The highest output was recorded in 2024, followed by 2023 and 2022, which highlights the expanding role of AI in STEAM education and the integration of AI-driven methodologies into interdisciplinary learning environments. The data also revealed a notable surge in publications beginning in 2020, a trend likely influenced by the COVID-19 pandemic and the corresponding reliance on AI-enhanced remote learning technologies. Between 2015 and 2019, output grew at a steady pace before accelerating significantly in the years following the pandemic. Prior to 2015, AI-STEAM publications remained relatively limited, with fewer than 4% of the total appearing annually. By contrast, early 2025 data include 252 publications in the first quarter alone, underscoring the continued momentum of research in this area.

Countries, Regions, and Affiliations

The geographical distribution of AI-STEAM research, as displayed in **Figure 2** and **Figure 3**, reveals notable disparities in publication output across countries and institutions, as indicated by Web of Science data (Clarivate, 2025). The United States leads the field, followed by China,

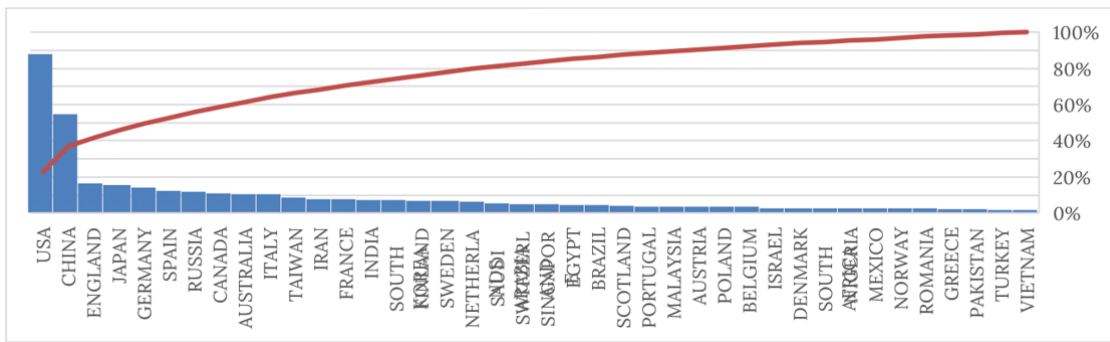


Figure 2. Top contributing countries/regions in AI and STEAM research (the author-generated visualization based on data exported from Web of Science core collection [Clarivate], coverage up to 2025 [accessed August 2025])



Figure 3. Affiliations with the highest contribution to AI and STEAM research (the author-generated visualization based on data exported from Web of Science core collection [Clarivate], coverage up to 2025 [accessed August 2025])

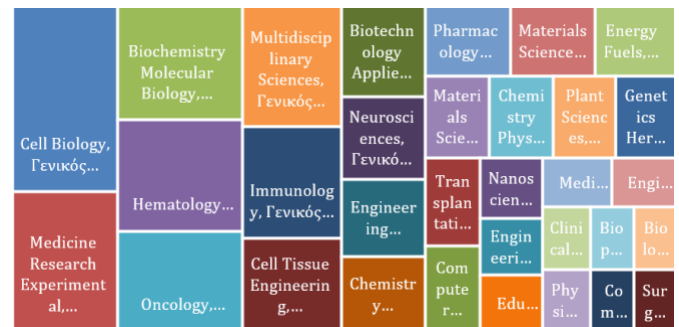


Figure 4. Distribution of research areas related to AI and STEAM (the author-generated visualization based on data exported from Web of Science core collection [Clarivate], coverage up to 2025 [accessed August 2025])

the United Kingdom, Japan, and Germany. These findings demonstrate that highly industrialized nations with strong research funding and advanced technological infrastructures dominate AI-STEAM research, reinforcing the global North's influence on educational AI developments. European countries such as Spain, Russia, France, and Italy have made moderate contributions, while developing nations, including Brazil, India, and South Africa, exhibit a smaller but steadily growing presence.

Overall, the data suggest that economic and technological resources play a decisive role in shaping research contributions, as wealthier nations with robust AI policies and STEAM education frameworks produce the highest publication volumes. Simultaneously, the expanding contributions from emerging economies point to a gradual broadening of the AI-STEAM discourse beyond traditionally dominant regions. At the institutional level, the Web of Science data (Clarivate, 2025) show that leading contributors include major research universities, AI-focused research centers, and STEAM-oriented institutes. The most prolific among them are Baylor College of Medicine, the Academy of Military Medical Sciences of China, Aga Khan University, Ain Shams University, and Addis Ababa University.

Themes

The thematic distribution of AI-STEAM research, as shown in **Figure 4**, based on the data from Web of Science

(Clarivate, 2025), reveals a strong concentration in biomedical sciences, engineering, and computer science, showing AI's dominant role in technology-driven interdisciplinary education. The largest research category is cell biology, followed by experimental medicine, biochemistry and molecular biology, and hematology, reflecting the prominence of AI applications in biomedical and life sciences. Engineering and computer science also represent major areas of focus, highlighting AI's centrality within STEM and computational learning frameworks.

By contrast, education-specific research remains relatively underrepresented, with education and scientific disciplines in education recording significantly fewer publications than STEM-oriented fields. This imbalance suggests that AI-STEAM research has prioritized technical and scientific applications over pedagogical approaches. Nonetheless, emerging areas such as AI-driven educational analytics, digital learning environments, and robotics in education are beginning to gain momentum. Moreover, AI-STEAM research demonstrates growing engagement with materials science, neurosciences, and pharmacology, illustrating its expanding cross-sectoral influence. Applications in simulation-based education, AI-driven experimentation, and computational modeling exemplify this trend. Furthermore, contributions in plant sciences, environmental sciences, and business economics point to a broadening of AI-STEAM applications beyond conventional laboratory and classroom contexts.

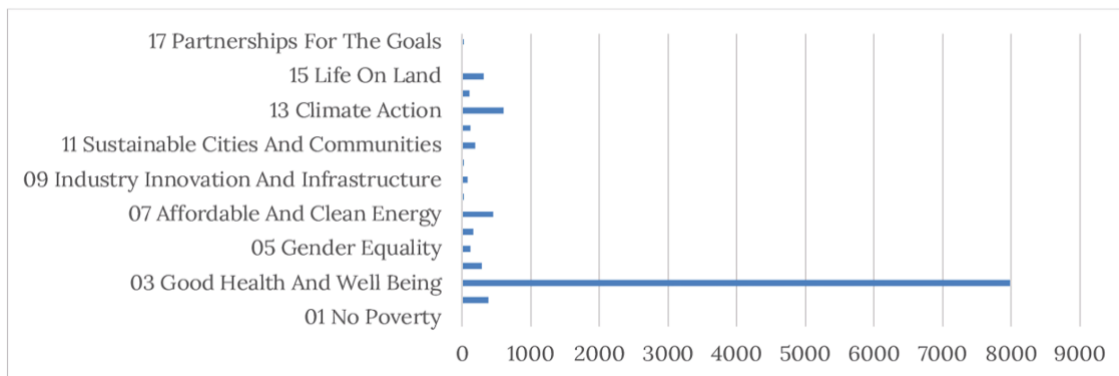


Figure 5. Publications mapped to SDGs (the author-generated visualization based on data exported from Web of Science core collection [Clarivate], coverage up to 2025 [accessed August 2025])

Sustainable Development Goals

The alignment of AI-STEAM research with the United Nations SDGs (Figure 5), as reflected in the Web of Science data (Clarivate, 2025), demonstrates a strong focus on health, environmental sustainability, and energy solutions. The most frequently addressed goal is SDG 3: Good health and well-being. This finding emphasizes AI's role in biomedical innovation, healthcare technologies, and digital health education and illustrates AI's expanding impact within medical and life sciences. Beyond health-related applications, SDG 13: Climate action and SDG 7: Affordable and clean energy emerge as significant areas of engagement. Research in these domains explores AI-driven climate modeling, energy-efficient AI applications, and the development of sustainable technologies. AI-STEAM research also contributes to SDG 2: Zero hunger and SDG 15: Life on land, particularly through studies on food security and biodiversity conservation. Collectively, these findings highlight the growing interdisciplinary link between AI-enhanced STEAM education and sustainability. By contrast, SDG 4: Quality education—which is directly connected to the core aims of STEAM education and AI-supported learning—appears in only 274 publications.

This relatively low number suggests that despite AI's transformative potential in education, its contribution to improving global learning access, teacher training, and educational equity remains underexplored. Socially oriented goals, such as SDG 5: Gender equality and SDG 10: Reduced inequalities, are also minimally addressed in AI-STEAM research. Therefore, future studies must focus on inclusive AI-driven education, ethical governance, and AI's potential role in addressing systemic inequities.

DISCUSSION

Building on these descriptive findings, this analysis examined publication trends, global research contributions, thematic emphases, and alignment with the SDGs in AI-STEAM scholarship. The results provide valuable insights for researchers, educators, and policymakers by identifying both the areas of strength and the domains where AI-enhanced interdisciplinary education can better address

persistent educational and sustainability challenges (Kavitha & Joshith, 2024; Supriyadi et al., 2023).

Publication Rates

The significant increase in the number of AI-STEAM research publications over the past decade aligns with broader trends in both STEAM education and AI in education, as documented in earlier bibliometric studies (Kavitha & Joshith, 2024; Supriyadi et al., 2023). The dataset reveals that publication output peaked in 2024, followed by 2023 and 2022. This trajectory mirrors patterns in STEAM research, where output accelerated after 2015 in response to policy reforms and technological advancements. The growth reflects a shift toward embedding AI-driven practices into interdisciplinary learning contexts (Marín-Marín et al., 2021).

The sharp increase in publication output after 2020 suggests that the COVID-19 pandemic served as a catalyst for the expansion of AI-STEAM research, a finding consistent with broader trends in AI-driven education (Lin & Yu, 2023; Pradana et al., 2023). As institutions worldwide transitioned to remote and hybrid learning, AI applications in STEAM disciplines became increasingly essential, particularly in automated assessment, curriculum personalization, and intelligent tutoring systems (Nan et al., 2025). This acceleration aligns with evidence that pandemic-related disruptions fostered greater adoption of AI-enhanced methodologies to support active and interdisciplinary learning (Tapullima-Mori et al., 2024).

Publication rates being relatively low before 2015 indicates that AI-STEAM scholarship was still in its early stages. This is consistent with the work of Su and Yang (2024), who observed that STEAM education itself was still emerging in the early 2000s, with emphasis on disciplinary integration. Growth in the mid-2010s coincided with the adoption of machine learning, big data analytics, and automation in STEM disciplines, which gradually expanded into interdisciplinary contexts (Rodrigues-Silva & Alsina, 2023).

The continuing upward trend suggests that AI-STEAM research is now a recognized and expanding field within educational innovation. Scholars increasingly focus on its

potential to enhance creativity, problem-solving, and computational thinking (Prahani et al., 2022; Verma et al., 2024). Nonetheless, gaps remain regarding how the integration of AI into STEAM education translates into effective and scalable learning models (Amanova et al., 2025).

Overall, this analysis confirms that AI-STEAM research has become a critical strand of contemporary educational discourse, driven by technological developments, policy shifts, and demand for digital learning solutions (Supriyadi et al., 2023). To consolidate these gains, researchers and policymakers must prioritize frameworks, funding initiatives, and curriculum designs that promote sustainable and equitable AI integration in interdisciplinary education. Future studies should also assess whether current growth trajectories will continue or stabilize as digital education policies mature (Rodrigues-Silva & Alsina, 2023).

Countries, Regions, and Affiliations

The geographical and institutional distribution of AI-STEAM research provides critical insights into global research capacity, technological advancement, and policy-driven educational innovation. The data indicate that the United States leads AI-STEAM research, followed by China, the United Kingdom, Japan, and Germany. This pattern reflects broader trends in both STEAM education and AI-driven learning, where technologically advanced and economically stable nations dominate publication output (Supriyadi et al., 2023). Similarly, the concentration of STEAM-related research in North America, East Asia, and Western Europe highlights the role of robust educational infrastructures and strong government support for innovation (Marín-Marín et al., 2021; Tapullima-Mori et al., 2024).

China's expanding publication output reflects strong national policy support for AI integration across sectors, including education, and the strategic prioritization of technological innovation. Institutions such as Tsinghua University and Beijing Normal University have emerged as leaders in developing AI-powered STEAM curricula and fostering international collaborations (Pradana et al., 2023). In the United States, long-standing investments in AI, digital education platforms, and interdisciplinary research underpin its global dominance, with universities such as Stanford, Massachusetts Institute of Technology, and Harvard pioneering AI-enhanced learning models (Afzaal et al., 2024; Verma et al., 2024).

The United Kingdom and Germany also play significant roles, supported by national strategies promoting digital literacy and interdisciplinary learning frameworks. European institutions, particularly in Spain and France, have focused on AI applications in teacher training and STEAM curriculum development, contributing to the regional diversification of research priorities (Amanova et al., 2025; Rodrigues-Silva & Alsina, 2023).

Emerging economies, including India, Brazil, and South Africa, show increasing engagement in AI-STEAM research,

although their contributions remain modest compared to those of wealthier nations. These trends highlight persistent disparities in research funding, technological infrastructure, and access to AI-driven educational resources (Tapullima-Mori et al., 2024). India has concentrated on AI applications in K-12 STEM education, while Brazil and South Africa have prioritized sustainability and AI-enhanced educational systems (Prahani et al., 2022; Supriyadi et al., 2023).

At the institutional level, medical and engineering universities dominate output. Baylor College of Medicine and the Academy of Military Medical Sciences in China exemplify this trend, emphasizing AI applications in biomedical education. This aligns with the high proportion of publications addressing SDG 3: Good health and well-being. By contrast, traditional faculties of education remain underrepresented, suggesting that while AI technologies are advancing rapidly, their pedagogical integration into STEAM education is less systematically explored (Jantakoon et al., 2024).

Overall, global AI-STEAM research remains concentrated in economically advanced regions, raising important equity concerns. Scholars stress the need for stronger international collaborations, targeted funding for low- and middle-income countries (LMICs), and the development of open-access educational technologies. Addressing these disparities will be crucial to ensuring that AI-driven interdisciplinary learning benefits diverse populations worldwide (Rodrigues-Silva & Alsina, 2023; Su & Yang, 2024).

Themes and Research Areas

The thematic distribution of AI-STEAM research demonstrates a strong emphasis on STEM disciplines, particularly biomedical sciences, engineering, and computer science. The most frequently represented areas include cell biology, experimental medicine, biochemistry, and molecular biology. These findings align with previous bibliometric studies that underscore the dominance of life sciences and engineering in STEAM-related research (Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023). Similarly, Marín-Marín et al. (2021) noted that biomedical applications and engineering solutions drive much of the global research in STEAM fields. AI integration into biomedical and engineering education has been shaped by advances in machine learning, data-driven diagnostics, and AI-assisted simulations, which support the increasing demand for practically oriented, technology-rich curricula (Afzaal et al., 2024).

Engineering and computer science also account for substantial proportions of the research output, highlighting AI's role in design thinking, robotics, and computational learning environments. These findings indicate growing interest in AI-enhanced problem-solving methodologies and coding education within STEAM frameworks. Researchers argue that such integration fosters computational thinking and algorithmic literacy, which are

key competencies in contemporary education (Jantakoon et al., 2024; Su & Yang, 2024; Tapullima-Mori et al., 2024).

Despite the interdisciplinary orientation of STEAM education, education-specific categories remain underrepresented. Both education research and scientific disciplines in education show comparatively low publication rates relative to STEM-focused areas. This imbalance suggests that although AI applications in technical disciplines are advancing rapidly, pedagogical investigations into AI's role in STEAM learning remain limited. Previous research has highlighted this gap, calling for greater emphasis on teacher training, interdisciplinary pedagogy, and curriculum development in AI-STEAM contexts (Pradana et al., 2023; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023).

Beyond core STEM fields, materials science, neurosciences, and pharmacology represent growing areas of AI-STEAM research, particularly regarding simulation-based learning and cognitive science. These findings reflect a broader movement toward experiential learning models incorporating virtual laboratories, AI-driven cognitive assessments, and advanced data visualization tools (Amanova et al., 2025). Plant sciences and environmental sciences also demonstrate AI's expanding role in sustainability education, reinforcing connections to climate literacy and global challenges (Kavitha & Joshith, 2024; Verma et al., 2024).

The limited emphasis on the arts and humanities within AI-STEAM research raises questions about how fully the "A" (arts) is integrated into the STEAM framework. Tapullima-Mori et al. (2024) argue that arts-based approaches enhance creativity and innovation yet remain underrepresented in AI-focused studies. Addressing this gap is essential for the development of holistic learning experiences that combine technical proficiency with creative problem-solving (Jantakoon et al., 2024; Su & Yang, 2024).

In summary, while AI-STEAM research demonstrates a high degree of interdisciplinarity, it remains heavily STEM-centric. To broaden its impact, future studies should expand the integration of AI into educational sciences, arts-based learning, and equity-driven pedagogies. Such efforts would allow AI-STEAM research to move beyond technological applications and better address holistic educational outcomes and societal needs (Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023).

Sustainable Development Goals

The integration of SDGs into AI-STEAM research underscores the complex interplay between technological advancement, interdisciplinary education, and global sustainability priorities. SDG 3: Good health and well-being having a clear dominance in the publication output reflects the strong emphasis on biomedical applications, healthcare innovation, and AI-driven medical education. This trend mirrors the broader research focus on life sciences and resonates with earlier bibliometric studies that also identified the health sector as central to AI-enhanced

interdisciplinary work (Afzaal et al., 2024; Rodrigues-Silva & Alsina, 2023; Supriyadi et al., 2023). The convergence of AI with STEAM in healthcare highlights the growing demand for educational programs that prepare students for AI-integrated medical and life science professions (Nan et al., 2025).

Environmental sustainability emerges as another major focus, particularly concerning SDG 13: Climate action and SDG 7: Affordable and clean energy. Research in these areas emphasizes AI-driven climate modeling, renewable energy education, and sustainability-oriented STEAM projects. Such approaches demonstrate the potential of AI-powered data analytics and simulations to engage learners in modeling real-world environmental challenges, fostering critical thinking, problem-solving, and climate literacy (Su & Yang, 2024; Tapullima-Mori et al., 2024; Verma et al., 2024).

By contrast, SDG 4: Quality education—which is most directly linked to the educational core of STEAM—remains underrepresented. While earlier studies have highlighted the importance of teacher training and inclusive STEAM learning models, relatively few publications explicitly focus on equity, accessibility, and pedagogical innovation. This imbalance suggests that AI-STEAM research has concentrated more on technological advancement than on practical applications for expanding educational access. Addressing this disparity is critical to ensuring that AI-STEAM initiatives contribute to equitable, high-quality education worldwide (Amanova et al., 2025; Jantakoon et al., 2024; Pradana et al., 2023; Supriyadi et al., 2023).

Other goals, including SDG 2: Zero hunger and SDG 15: Life on land, point to AI-STEAM applications in agricultural technologies, food security education, and biodiversity conservation. However, socially oriented goals, such as SDG 5: Gender equality and SDG 10: Reduced inequalities, remain marginal in this body of research, reinforcing concerns that inclusivity and equity are underexplored in AI-STEAM scholarship (Rodrigues-Silva & Alsina, 2023). Expanding research in these areas would help ensure that AI-STEAM frameworks not only advance technological knowledge but also promote social responsibility and global citizenship (Kavitha & Joshith, 2024; Lin & Yu, 2024).

Taken together, the analysis reveals that AI-STEAM research predominantly aligns with technologically intensive SDGs, with comparatively limited attention to education, equity, and social well-being. Scholars increasingly call for interdisciplinary collaborations, policy-driven incentives, and inclusive curriculum design that embed AI and STEAM within a sustainability framework, thereby linking innovation with broader societal impact (Tapullima-Mori et al., 2024; Verma et al., 2024).

CONCLUSIONS

This bibliometric analysis of AI-STEAM research highlights key insights into publication trends, global contributions, thematic emphases, and alignment with the

SDGs. The rapid growth of publications, particularly after 2020, underscores the expanding recognition of AI as a transformative force in interdisciplinary learning. This surge reflects the combined influence of technological advancements, global educational reforms, and the COVID-19 pandemic, which accelerated the adoption of AI-driven remote learning and personalized educational technologies (Nan et al., 2025; Pradana et al., 2023; Supriyadi et al., 2023). Collectively, these developments signal a paradigm shift in education, with AI increasingly regarded as essential for building innovative, flexible, and inclusive STEAM learning models (Rodrigues-Silva & Alsina, 2023).

The geographical distribution of research, however, reveals persistent inequalities. The United States and China dominate publication output, while contributions from emerging economies remain limited in number. This imbalance echoes earlier findings regarding unequal access to research funding, digital infrastructure, and AI-related resources (Tapullima-Mori et al., 2024; Verma et al., 2024). Addressing these disparities requires targeted strategies, including international collaborations, the development of open-access AI platforms, and sustained capacity-building initiatives. Policymakers and funding agencies should prioritize equitable research partnerships to ensure that AI-STEAM innovations extend to LMICs and support diverse educational contexts (Amanova et al., 2025; Su & Yang, 2024).

Thematic patterns in AI-STEAM scholarship show that biomedical sciences, engineering, and computer science dominate research output. While these fields employ AI for simulation-based learning, data analytics, and problem-solving, the underrepresentation of education research raises concerns about the limited pedagogical integration of AI (Jantakoon et al., 2024; Supriyadi et al., 2023). Greater attention is needed to investigate how AI affects teaching methodologies, teacher preparation, and inclusive curriculum development. Expanding the role of the arts and humanities within AI-STEAM frameworks could enrich holistic learning experiences, fostering creativity, ethical reasoning, and socially responsible innovation (Tapullima-Mori et al., 2024).

In terms of SDG alignment, the prominence of SDG 3: Good health and well-being confirms the biomedical orientation of the majority of the publication output, reflecting the global momentum of AI-enabled healthcare applications. Yet the comparatively limited attention to SDG 4: Quality education points to a disconnect between technological innovation and educational equity (Afzaal et al., 2024; Verma et al., 2024). Given AI's potential to enhance access, personalization, and inclusivity in education, future research must prioritize AI-supported approaches that advance equitable, high-quality learning systems (Su & Yang, 2024). Furthermore, the minimal engagement with socially oriented goals such as SDG 5: Gender equality and SDG 10: Reduced inequalities underscores the need for AI-STEAM initiatives that explicitly address social inclusion and justice (Rodrigues-Silva & Alsina, 2023)

RECOMMENDATIONS

Building on the findings, three key recommendations emerge. First, greater emphasis should be placed on the pedagogical applications of AI in STEAM, particularly in teacher training and student-centered learning models, to ensure that technological innovation translates into effective educational practice. Second, promoting global equity in AI-STEAM research through collaborative projects, open-access data repositories, and targeted funding is essential for broadening participation and impact across diverse contexts. Third, sustainability and ethics must be integrated into AI-STEAM curricula more explicitly, fostering responsible innovation and aligning educational practice with global priorities (Supriyadi et al., 2023).

Limitations

This study has several limitations. First, the analysis is based solely on publications indexed in the Web of Science database, which may exclude regional journals and non-English-language publications, thereby limiting the completeness of global representation. Second, given the rapid evolution of AI technologies, the dataset may not fully capture the most recent developments and applications in AI-STEAM contexts. Finally, the study did not extend to evaluating policy implementation or classroom-level practices, which remain important areas for future investigation (Donthu et al., 2021).

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